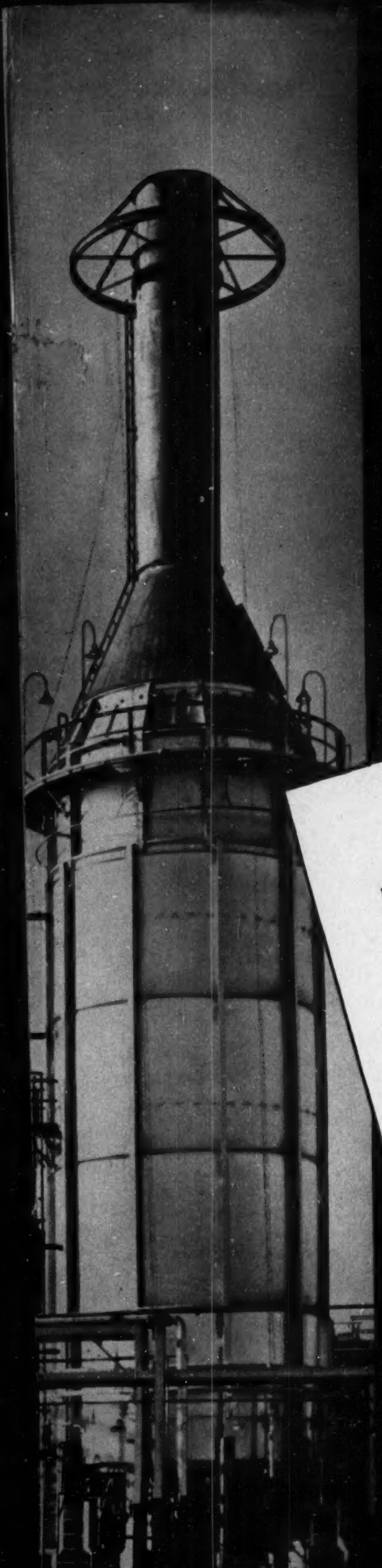
Chemical Engineering

JUNE 1953



HEAT TECHNOLOGY

- Production
- Containment
- Transport
- Transfer
- Application

A 60-page report on current theory and practice

A McGRAW-HILL PUBLICATION

ONE DOLLAR

GUIDED TOUR JOHN R. CALLAHAM, EDITOR

Photo courtesy Standard Oil Co. (N.J.)

. . . Today's heat technology shows new trends all along the line.

Take any aspect of heat technology—fuels, combustion, refrigeration, furnaces, metals, refractories, insulation, transfer media, heat transfer—and you'll find new technological trends on the horizon.

Here, in a 60-page report, we take an over-all look to show how recent advances affect the design and operation of chemical plants (*Feature Report*).

Quick way to get power plant costs.

Here's a set of simple factors you can use to estimate the cost of your complete power plant. Yes, they take into account such things as process steam requirements, back pressure conditions, present price levels (*Feature Article*).

Any trouble with materials handling?

Then you might learn a trick or two from these stories of seven mishaps and what caused them. They're from the experiences

Please turn page

Plastics in Process Equipment

Plastics are fast taking their place beside metals as prime materials of construction for the chemical process industries. For some jobs they're better than metals.

But where can you get the low-down on what plastics to use where—and why? Many of them are so new there's no backlog of experience, no handbooks to serve as a guide.

Next month DuPont's W. M. Bruner will come forth with a feature report that will answer a lot of the questions every chemical engineer asks about the use of plastics in processing equipment.

What are the basic and critical properties of each material? What about their top service temperatures? How do they stack up in resistance to corrosive chemicals? Where are they now being used in chemical process equipment? What's the price range of plastic pipe?

You'll find Dr. Bruner's report in our next issue.

GUIDED TOUR

of W. G. Hudson, authority on materials handling (*Feature Article*).

Six advances on five fronts.

Esso's latest fluid cat cracker sports a brand new catalyst circulation system. No throttling slide valves: easier process control, more stable operations.

Carrier's high-vacuum, vertical falling-film concentrator brings new hopes for cutting down scale, corrosion and concentration costs for many chemicals.

Ross & Roberts worked out nifty ways to control dusts in vinyl operations. Two other plastics plants go to the Tote way of moving bulk solids. No dust, waste, or heavy labor.

American Cyanamid cooks up a simple inter-plant haulage scheme that hikes labor efficiency, slashes maintenance costs.

And Norwich Pharmacal puts smart engineering into its new aspirin plant, comes up with one of the most up-to-date units of its kind anywhere (*What's Happening*).

Rejoin GUIDED TOUR page 289

JUNE 1953

Chemical Engineering

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CHEMICAL ENGINEERING

June 1953 Vol. 61—No. 6

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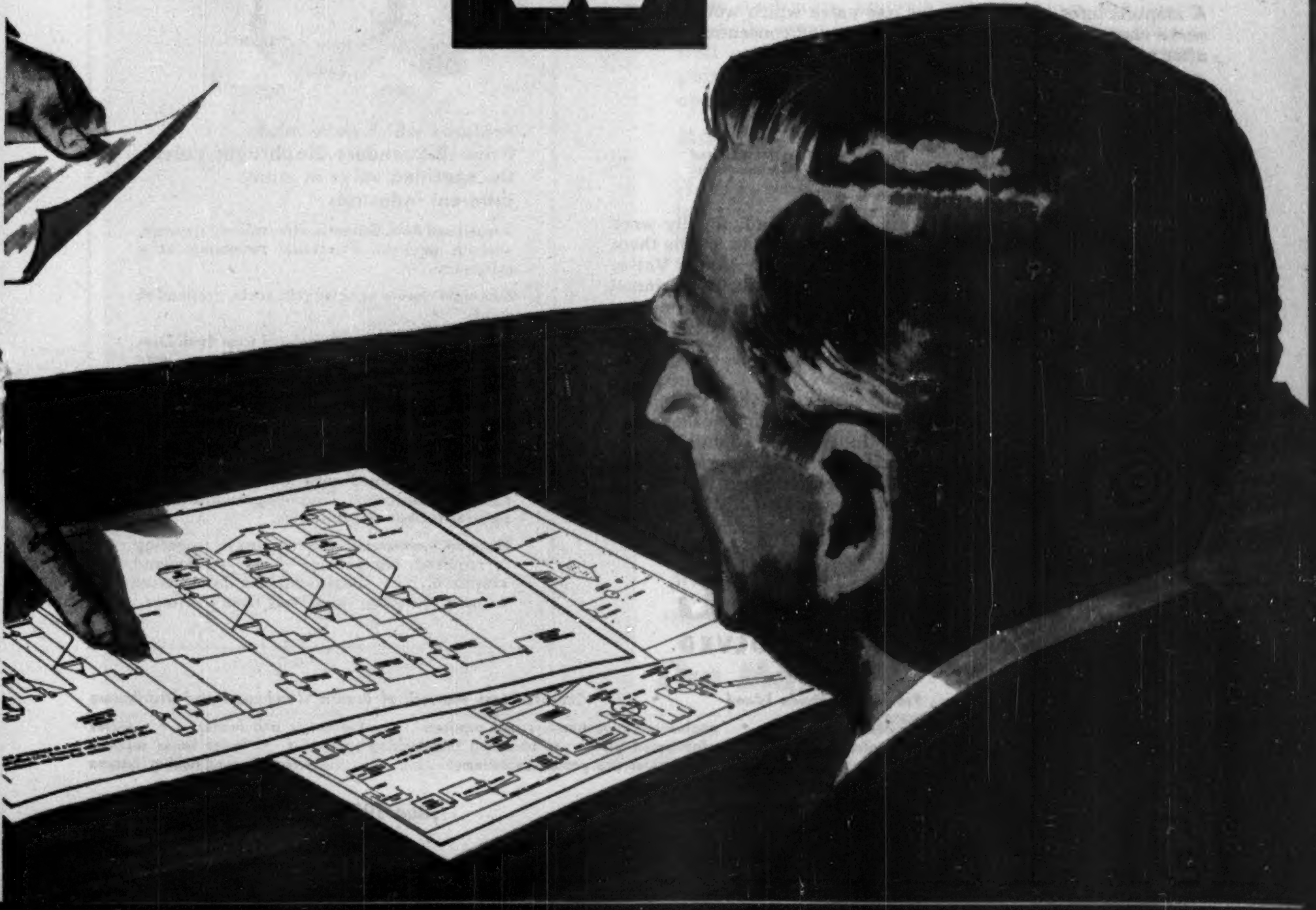
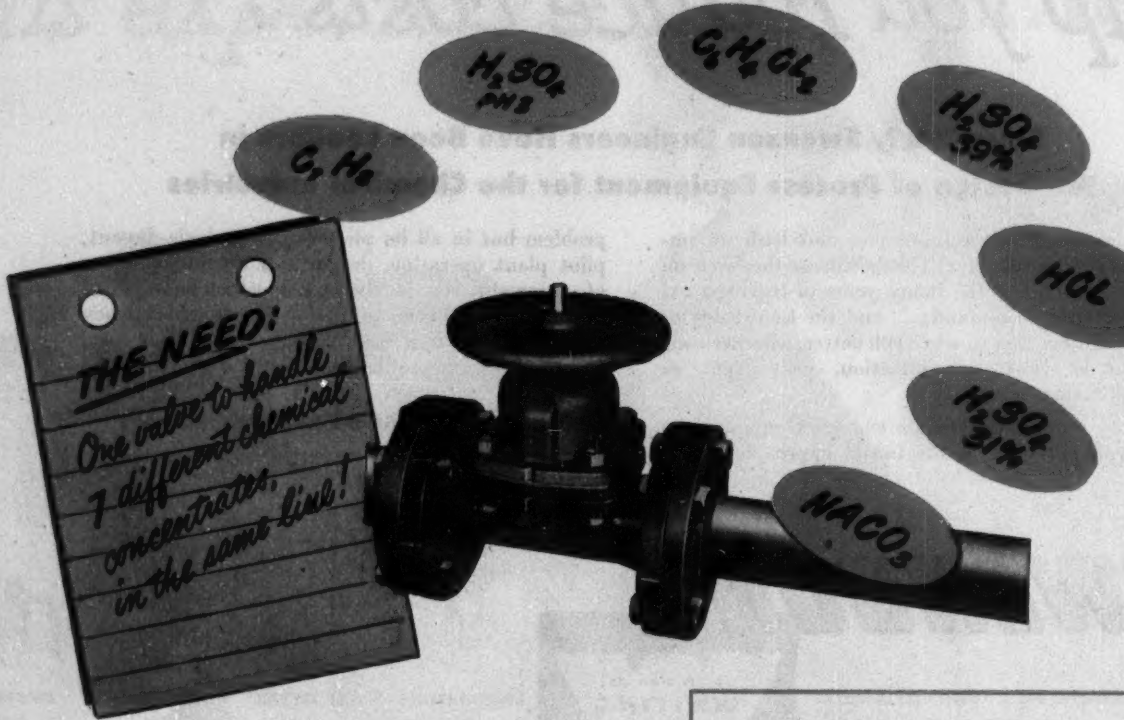
His experience ...will



TROUBLE multiplied by 7



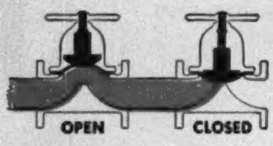
A manufacturer was looking for *one valve* which would handle *seven chemicals* of varying temperatures and concentrations, one after another, in the same line. They were . . .

SODIUM CARBONATE	PH 9	90°C
HYDROCHLORIC ACID	8%	100°C
SULPHURIC ACID	PH 3	20°C
SULPHURIC ACID	39%	42°C
SULPHURIC ACID	31%	15-20°C
TOLUENE	*(Full strength but associated with traces of other chemicals)*	

ORTHODICHLOROBENZENE — Cleaning Solvent

Valves suitable for use with these chemicals individually were available. But only *one valve* was found which could handle them in combination. It was the Grinnell-Saunders Diaphragm Valve, glass lined, with chemically inert KEL-F Diaphragm. The Grinnell KEL-F diaphragm not only prevented the liquid from attacking working parts, but it eliminated leakage around the stem.

Piping in today's complex industrial plants is an exacting science involving the handling of highly corrosive fluids, gases, compressed air, beverages, foods and suspended solids . . . in lines where corrosion, abrasion, contamination, clogging, leakage and maintenance are costly factors. Under such conditions, the amazing adaptability of the Grinnell-Saunders Diaphragm Valve explains its acceptance by industry after industry. For further details, write for Grinnell-Saunders Diaphragm Valve Catalog.



Features which have made Grinnell-Saunders Diaphragm Valves the specified valve in many different industries:

Streamlined flow. Smooth, streamlined passage, without pockets. Frictional resistance at a minimum.

Leak-tight closure against grit, scale, suspended solids.

Working parts absolutely isolated from fluid. Diaphragm completely seals off working parts from fluid in the line.

Body, lining and diaphragm materials to meet service condition. Bodies stocked in cast iron, malleable iron, stainless steel, bronze and aluminum; other materials on special orders. Valve bodies lined with lead, glass, natural rubber or neoprene. Diaphragm materials of natural rubber or synthetics.

Minimum maintenance. No refacing or reseating is required. No packing glands to demand attention. New diaphragm can be inserted without removing valve body from the line.

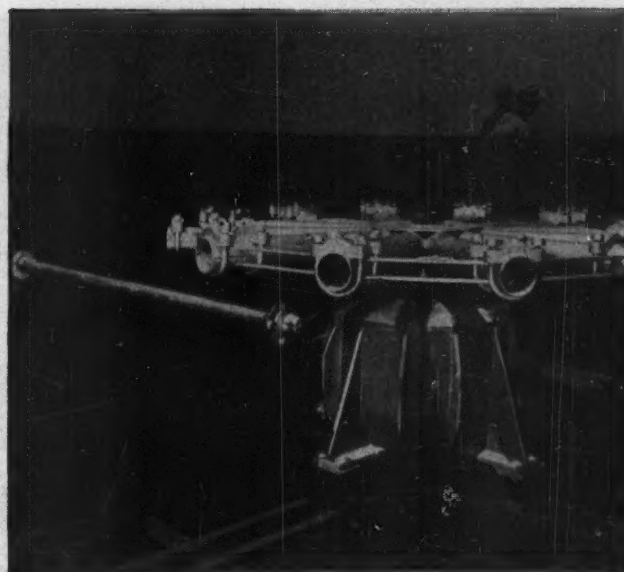
GRINNELL

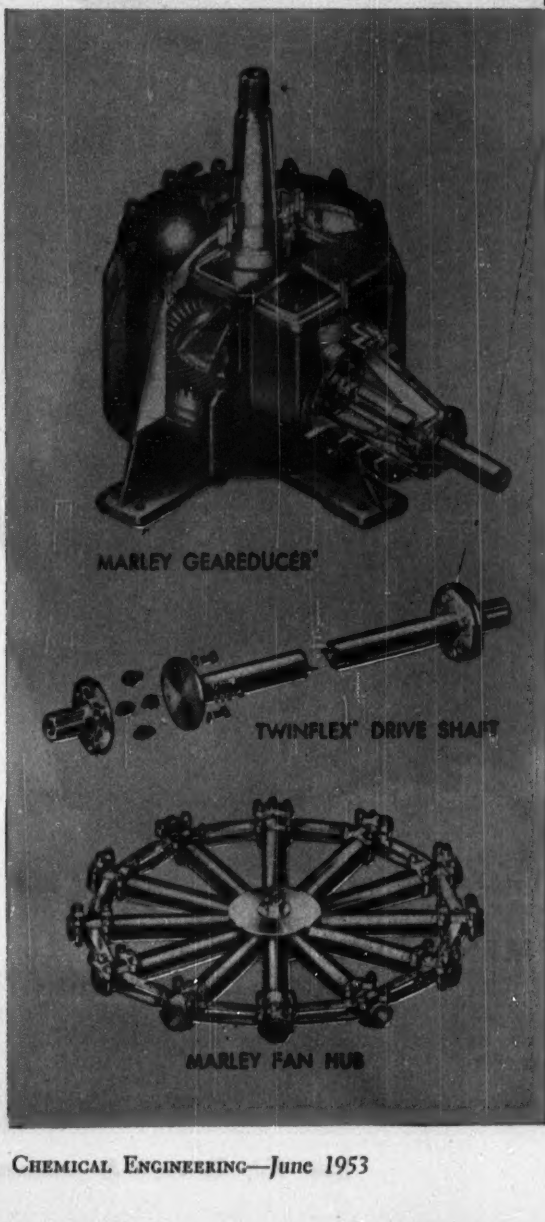
WHENEVER PIPING IS INVOLVED

Grinnell Company, Inc., Providence, Rhode Island • Coast-to-Coast Network of Branch Warehouses and Distributors

pipe and tube fittings • welding fittings • engineered pipe hangers and supports • Thermolier unit heaters • valves
Grinnell-Saunders diaphragm valves • pipe • prefabricated piping • plumbing and heating specialties • water works supplies
industrial supplies • Grinnell automatic sprinkler fire protection systems • Amco air conditioning systems

MARLEY Mechanical Equipment is POWERED for PERFORMANCE





Driving the large fans of modern cooling towers is a rugged job . . . one that demands power transmission equipment designed with an extra measure of sturdiness. With its added strength it must also be precision built for long, smooth service. That's why Marley designs and manufactures every element of the mechanical equipment for Marley cooling towers. The result is specialized equipment for a specific service.

MARLEY GEAREDUCER*

An exclusive Marley design utilizing hardened alloy steel gears, tapered roller bearings and heavy, carefully machined shafts—all in an extra strong, well sealed, cast iron case. Lubrication to every point is constant and flow is maintained whether operation is forward or reverse.

MARLEY TWINFLEX* DRIVE SHAFT

This accurately balanced assembly is constructed of heavy steel tubing zinc-coated and sealed against internal corrosion by welded flanges. It transmits power to the cast steel yoke through pre-moulded neoprene inserts bonded to cadmium plated steel cores. They have excess load capacity that easily absorbs starting shock and transmits power smoothly.

MARLEY FAN HUB

This hub for largest fans is of all-steel construction. Hub spokes are seamless steel tube; center hub and clamps are steel castings. It is precision welded throughout for great strength. After fabrication, the hub is hot dip galvanized. The design provides quick adjustment for fan pitch and uses a retention pin for added safety.

Any Cooling Tower May Be Modernized with Marley Mechanical Equipment

*Registered trade mark

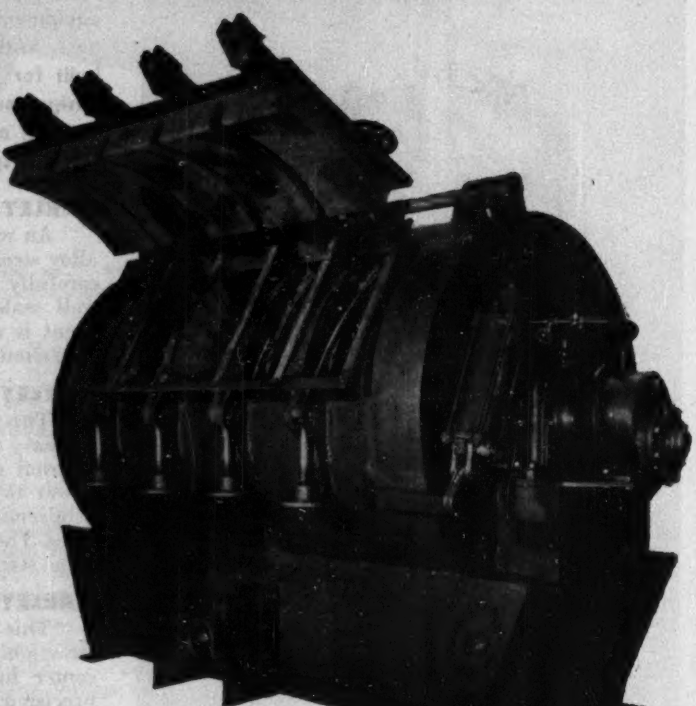
The Marley Company

MARLEY

Kansas City, Missouri

- **kept closed during operating cycle**
- **can be built to fit your needs**

Conkey Rotary Leaf Pressure Filter



Conkey Rotary Leaf Pressure Filters are kept totally closed during the entire operating cycle. This closed cycle operation means safer, more economical operation, less cloth expense. Volatile liquids are handled with negligible loss. Danger to operator from corrosive liquids is minimized.

These Conkey units eliminate the heavy manual labor usually associated with cyclic pressure filtration. Ingenious design requires only valve manipulation for all filtration cycles, including cake discharge.

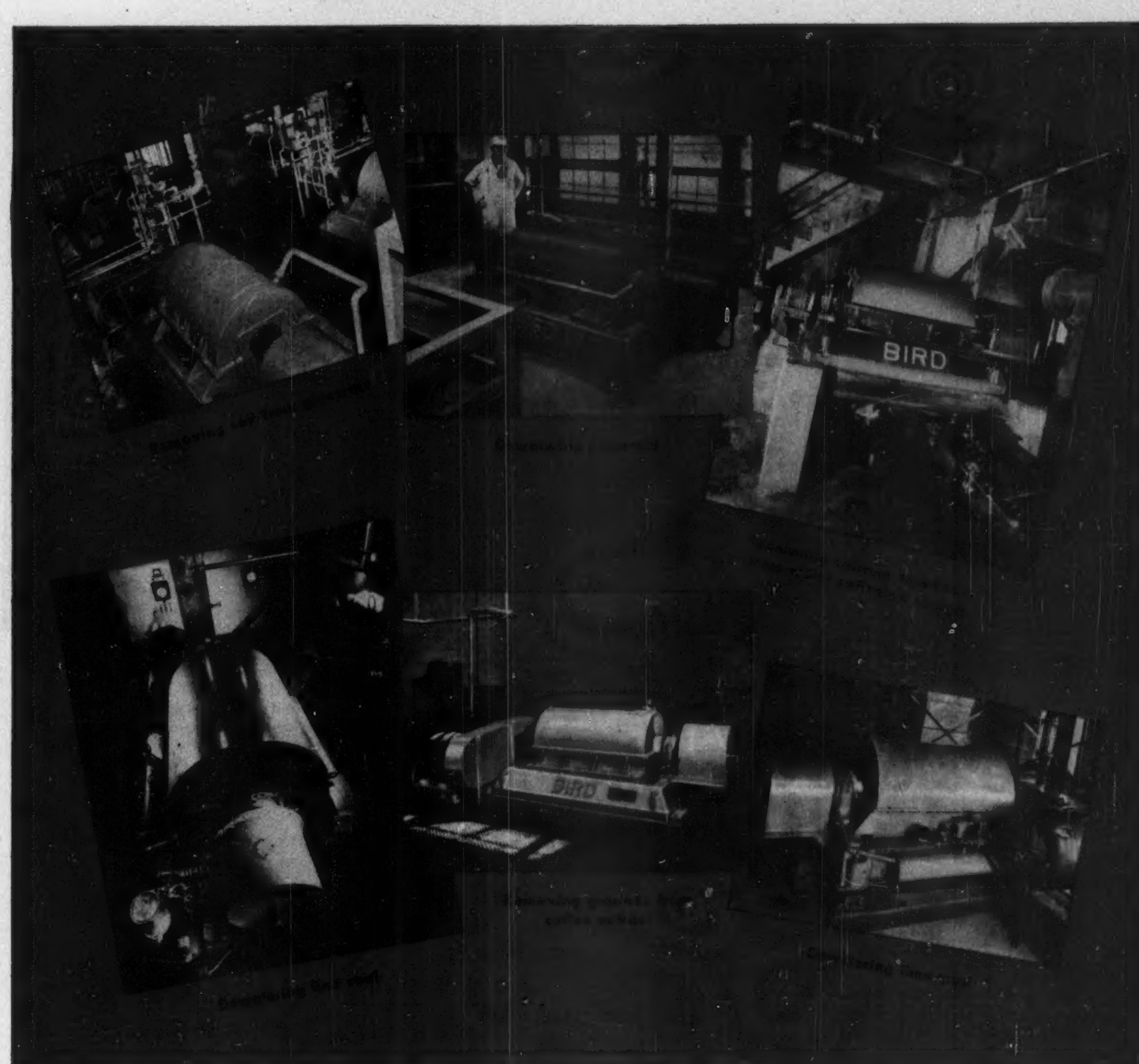
Slow rotation of the filter leaves results in superior filter performance. Settling is retarded. Less filter aid is required for precoating operations. A non-tapering cake is built over the entire filter surface. Washing is better, discharging is clean and complete.

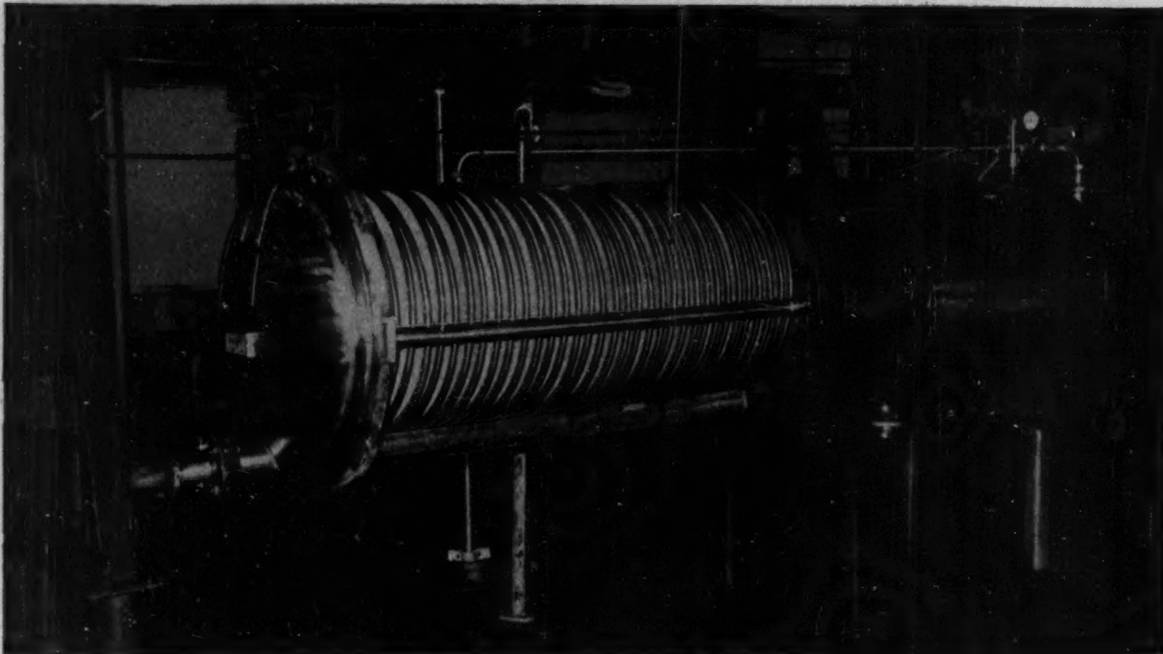
Conkey filters are available in a complete selection of standard size units—from the laboratory unit of three square feet of surface to the industrial unit of 1800 square feet of filter surface. They can be built in a wide range of sizes and materials for practically every purpose.

Send for latest bulletin on Filters

PROCESS EQUIPMENT DIVISION
GENERAL AMERICAN TRANSPORTATION CORPORATION

Sales Office: 10 East 49th St., New York 17, N.Y.
General Offices: 135 S. LaSalle St., Chicago 90, Illinois
In Canada: Canadian Locomotive Co., Ltd., Kingston, Ont.
Offices in all principal cities
Other General American Equipment: Turbo-Mixers • Evaporators • Dewaterers • Towers
Tanks • Bins • Dryers • Pressure Vessels.





AMAZINGLY FAST CLEANING All-metal filter leaves roll out of filter as a unit. Operator taps the leaves to drop cake into trough, hopper, or wagon. Then he returns clean leaves into filter which locks pressure-tight with one swift motion.

Here's a *BIG* filter that costs less to operate

The Niagara Style "H" Filter will filter liquids to high clarity, at rates up to 30,000 GPH.

It also gives you easy recovery or disposal of as much as 150 cu. ft. of solids at a time.

Sizes range up to 1,500 square feet of working filter area in one compact, leakproof unit.

CLEANED IN A FEW MINUTES

Cake discharge is faster than anything you've ever seen in a filter this big. Cakes can be blown dry in the filter, are then dropped into a discharge hopper simply by rapping the all-metal leaves with a rubber mallet. That's all there is to it.

The filter in the picture is opened, cleaned, and closed in less than ten minutes, by one man. It can be taken off-stream, drained, opened, cleaned, closed, filled, and precoated in less than 30 minutes.

IDEAL FOR CORROSION RESISTANCE

The simple fabricated shell can be constructed in stainless steel and special alloys for corrosion resistance, and can be readily and cheaply jacketed. Special construction, to match your needs, costs far less than usual for a filter of this size.

COMPLETE FILTRATION SERVICE

How can we help you? We're equipped to test samples for filterability . . . pilot the filtration for you . . . design, build and install a filter or a complete system to fit your process.

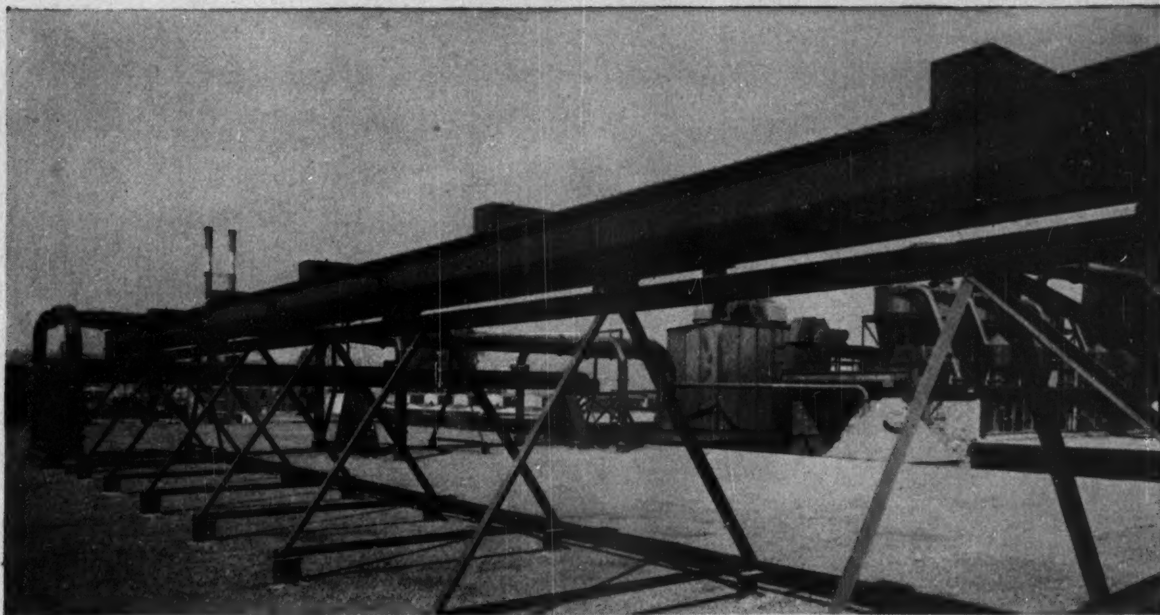
NIAGARA VERTICAL FILTERS are leakproof, pressure-tight; quickly cleaned between cycles by one man. All-metal leaves usually require no cloths.

To get details quickly, just write us or mail the coupon today.

Niagara Filter DIVISION
AMERICAN MACHINE AND METALS, INC.

Engineering and Sales Office: 3087 Main St., Buffalo 14, N. Y.
(When writing, please use above address)
Factory: East Moline, Illinois
***IN EUROPE:* Niagara Filters Europe, 36 Leidsegracht, Amsterdam-C, Holland**

NIAGARA FILTER Division, American Machine and Metals, Inc.
3087 Main St., Buffalo 14, N. Y.
Please send information on Niagara Filters for ________ (product or operation)
Name________
Title________
Company________
Address________
City________ Zone____ State____



On roof above storage bins, this 14-in. diam. Helicoid screw conveyor is one of 30 Link-Belt screw conveyors transporting soybean meal from receiving hoppers to storage bins, or to processing.

There's no substitute for "total engineering" in screw conveyors

LINK-BELT integrates all components to give you the right screw conveyor for your job

HERE'S how "total engineering" works for you when you buy Link-Belt Screw Conveyors.

First, conveying specialists analyze your problem. Then, Link-Belt's vast experience in design and manufacture is at your command to recommend the screw conveyor—or system of conveyors—for your particular requirements. The right components are then selected from Link-Belt's complete range of types and sizes.

Link-Belt "total engineering" on your screw conveyors is your assurance of efficient design . . . balanced performance.

To benefit from Link-Belt's materials handling experience and engineering service, contact the Link-Belt office near you.

LINK-BELT designs and builds all components

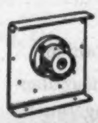
SCREWS—Link-Belt makes a complete range of conveyor screws—Helicoid, Sectional Flight, Cut Flight, Ribbon Flight, Paddle type and other special types for such diverse applications as feeding, conveying, mixing, agitating, stirring, blending, etc.

HANGERS—Available in a variety of styles and mountings, with various bearing materials and steel or cast hanger frames.

TROUGHS—Link-Belt builds flanged, angle flanged, flared, rectangular, dust-seal, jacketed and drop-bottom types in steel or alloy metals. Variety of connections, supports, covers and clamps offers added design flexibility.

SPOUTS & GATES—Plain discharge spouts can be fixed or detachable. Discharge gates, flat or curved slide, can be hand or rack-and-pinion operated.

SHAFTS & COUPLINGS — Conveyor couplings and end shafts are designed for adequate torsional strength and have jig-drilled coupling bolt holes for accurate alignment.



TROUGH ENDS—Steel or alloy metal plate or cast trough ends to match all trough shapes, provide required shaft bearing support and alignment. Seal glands to protect bearings, if required.

DRIVES — Link-Belt designs and builds many forms of drives to suit specific conditions—Enclosed gear, Electrofluid, P.I.V. variable speed, and chain drives of various types.

LINK-BELT

SCREW CONVEYORS

13,187

LINK-BELT COMPANY: Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8, Springs (South Africa). Offices in Principal Cities.

Her fingertips imagine the taste

The lady doesn't trust her eyes alone.

The buyer of Multiwalls is in much the same position.

Aside from package design, it's hard to tell one manufacturer's bag from another's simply by looking at it or fingering it.

Put the bags out of sight and you may be able to see many differences.

Men who buy 85 per cent of all Multiwalls consider* these intangibles more important than any other factor when they choose their supplier.

Invariably, these are among the first questions they ask . . .

"Is this company big enough?"

"Do they have a fair allocation policy?"

"Are their prices competitive?"

"Do they respect delivery dates?"

In a nutshell—

"Are they good people to do business with?"

We can't tell you what the answers are when these Multiwall users consider Union. This we do know . . . and the inference is yours to make—

In these days of industrial pressure, when *dependability* is a fervent wish as well as a word, men to whom Multiwalls are important are placing an increasing share of their orders with Union.

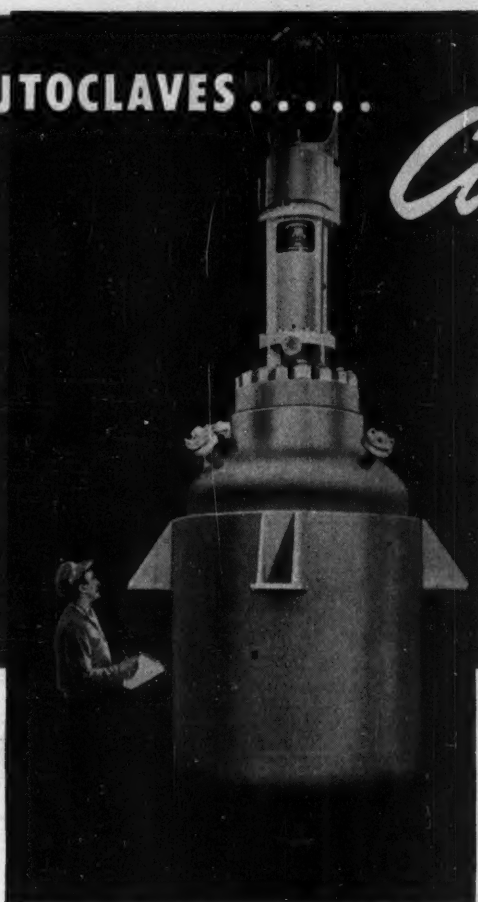
More so every day . . .

IT'S UNION FOR MULTIWALLS

**August, 1951 research study.*

UNION BAG & PAPER CORPORATION • NEW YORK: WOOLWORTH BUILDING • CHICAGO: DAILY NEWS BUILDING

AUTOCLAVES..... *Custom Built*



A 500 gallon, 1875 PSI Autoclave designed and built by Blaw-Knox for processing an additive for aviation gasoline.

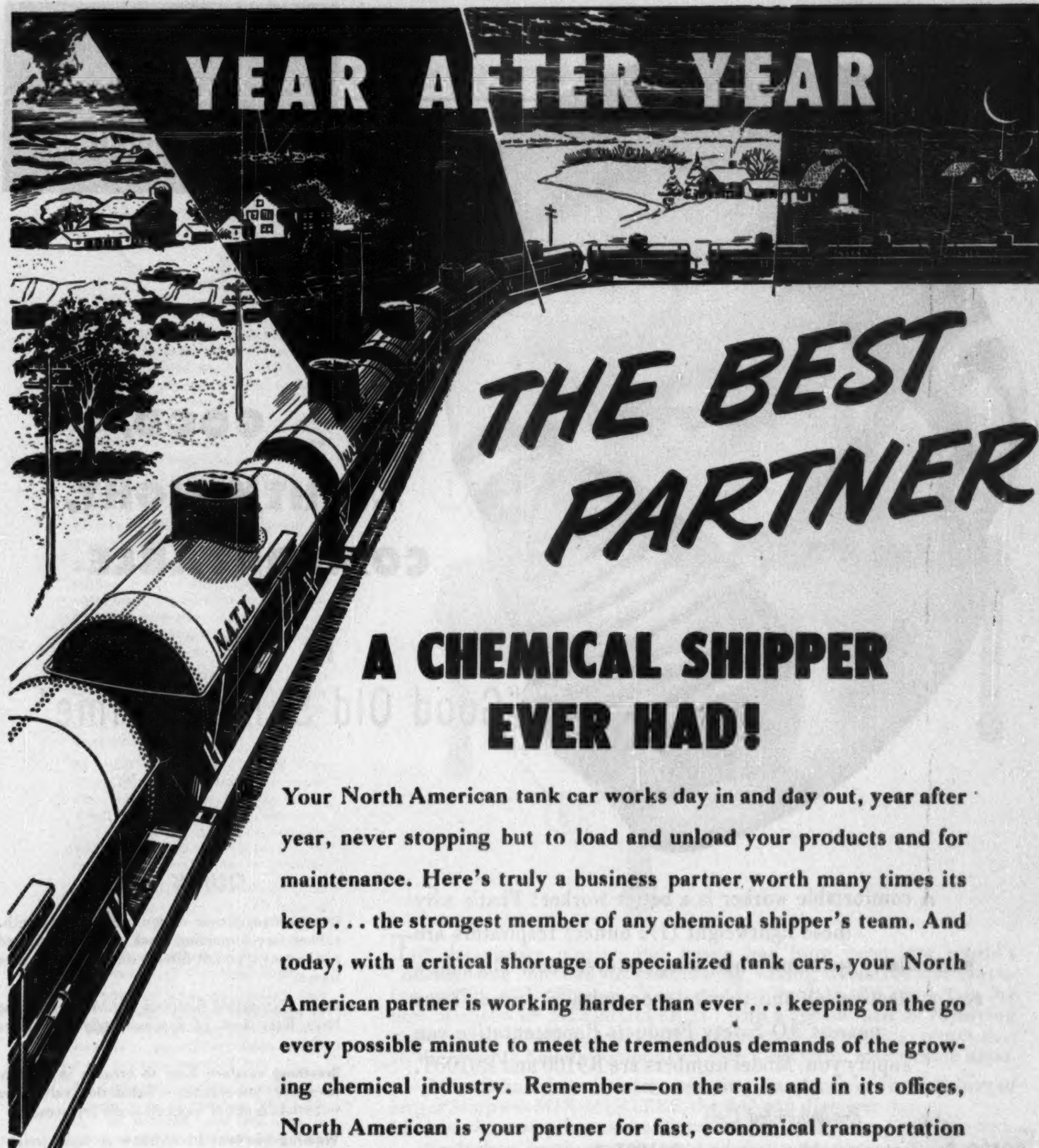
IN ANY CAPACITY
FOR ANY PRESSURE
ANY TEMPERATURE
ANY REACTION

Time and expense are saved, doubts and experiments eliminated when you turn your Process Equipment problems over to Blaw-Knox. Long experience in both design and fabrication assures your autoclave or other reaction vessel of high performance, maximum safety and ruggedness for long service. Working from clients' drawings or our own designs Blaw-Knox Equipment Division has built highly successful autoclaves for:

ESTERIFICATION—Production of esters through alcohol-acid reactions... **POLYMERIZATION**—Reactions involving the addition or agglomeration of molecules to increase molecular weight... **SULFONATION**—Reactions with organic compounds employing the sulfonic acid group... **ORGANIC SYNTHESIS**—Combination, reaction, or mixing of various organics... **NITRATION**—Chemical reactions involving combination or treatment with the nitro group... **HYDROGENATION**—Reactions of combination or reduction with hydrogen... **ALSO:** Ammonolysis... Emulsification... Impregnation... Halogenation... Crystallization... Sublimation... General High Pressure Processing, Etc.

BLAW-KNOX

BLAW-KNOX COMPANY
BLAW-KNOX EQUIPMENT DIVISION
PITTSBURGH 22 PENNSYLVANIA



THE BEST PARTNER

A CHEMICAL SHIPPER EVER HAD!

Your North American tank car works day in and day out, year after year, never stopping but to load and unload your products and for maintenance. Here's truly a business partner worth many times its keep . . . the strongest member of any chemical shipper's team. And today, with a critical shortage of specialized tank cars, your North American partner is working harder than ever . . . keeping on the go every possible minute to meet the tremendous demands of the growing chemical industry. Remember—on the rails and in its offices, North American is your partner for fast, economical transportation and helpful, experienced shipping advice.

For Special Products Requiring Special Care

NORTH AMERICAN CAR CORPORATION

NORTH WESTERN REFRIGERATOR LINE COMPANY

A NATIONWIDE ORGANIZATION WITH BRANCH OFFICES IN IMPORTANT MARKET CENTERS

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RIO GRANDE NATIONAL BLDG., DALLAS, TEXAS — SHELL BUILDING, ST. LOUIS 3, MO.

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91 SOUTH MAIN STREET, FOND DU LAC, WIS. — 739 PILLSBURY AVENUE, ST. PAUL 4, MINN.

Dust Respirators

GOOD,
LIGHTWEIGHT,
COMFORTABLE

In the
"Good Old Summer Time"

A comfortable worker is a better worker! That's why these lightweight (1½ ounce) respirators are particularly welcome when temperatures soar. They do a real protective job and they're economically priced. Your nearest AO Safety Products Representative can supply you. Model numbers are R9100 and R9100T.

Recommended Uses

R9100 Respirator provides protection against pneumoconiosis-producing and nuisance dusts such as borax, carbon, glass, grain, graphite, cement, limestone, gypsum, coke, charcoal, wood, pollen, flour and aluminum.

R9100T Respirator, similar in appearance and construction to the R9100, protects against any toxic dusts not considerably more toxic than lead—such as arsenate of lead, barium, cadmium, and manganese. It also protects against DDT.

QUICK FACTS

Construction: Simple design includes a smooth, rubber face-contacting mask and a corrugated permanent type felt filter, reinforced by a wire frame.

Filter: Corrugated facepiece forms filter, giving large filter area of approximately 22 square inches.

Breathing comfort: Easy to breathe in — non-reversing, low-resistance exhalation valve does not stick, is out of way and easily replaceable.

Wearing comfort: In addition to light weight, comfort features include soft rubber, smooth edges and self-adjusting double headband.

Unobstructed visibility: Compact, fits close to face. May be worn under helmet or with goggles.

Easily cleaned: A vigorous shake, a slap of the hand or a light blast from an air hose removes dust.

Both respirators are approved by the U. S. Bureau of Mines (R9100 — BM2137, R9100T — BM2144).

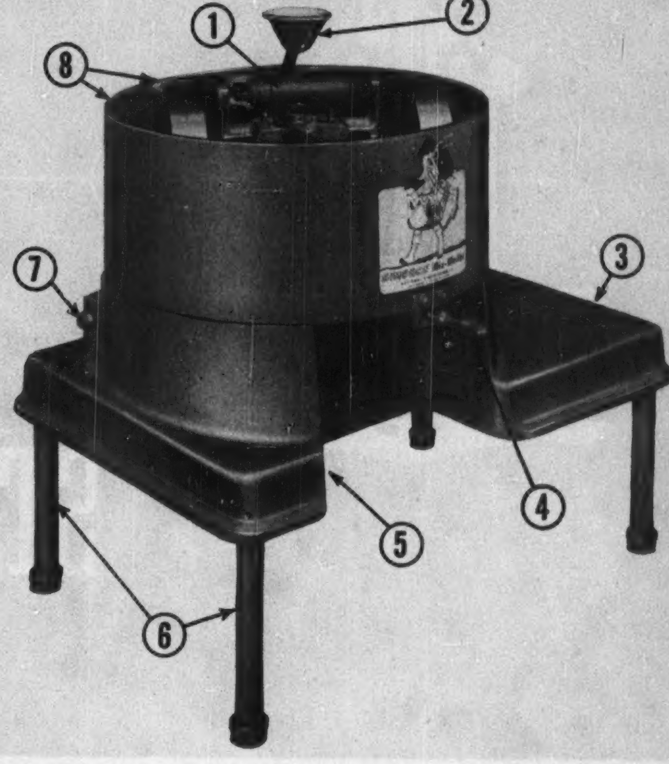
Look to AO for a complete line of safety goggles, protective clothing and respirators for every industrial need.

American Optical

SOUTHBRIDGE, MASSACHUSETTS • BRANCHES IN PRINCIPAL CITIES

Here's your modern "Mortar and Pestle" for accurate laboratory mixing

The *NEW* SIMPSON *LF* *MIX-MULLER*



1. SPRING-LOADED MULLERS . . . designed to exert more or less pressure, as adjusted. Mullers weigh only 30 lbs. but can be adjusted to exert up to 80 lbs. pressure.

2. ADDITIONS FUNNEL — DUST COVER . . . arranged so the funnel directs liquid additions *directly* to the material bed—without removal of dust cover or splashing of liquids. Tight fit of light spun-metal cover assures dust-free operation. (Head not shown in photo.)

3. WORKING AREA . . . integral casting of mixer and motor base provides adequate working area for tools or other laboratory appliances . . . also assures proper and permanent alignment of drive.

4. CIRCULAR LEAK PROOF DISCHARGE DOOR . . . machined for tight fit and smooth operation. Large door, clear space provides for quicker discharge of batch.

5. V-BELT DRIVE — TORQUE ARM REDUCER . . . completely yet accessibly enclosed beneath base plate. V-Belt drive assures flexible operation . . . and easier, lower maintenance. Vertical mounted motor is readily accessible for maintenance or removal.

6. REMOVABLE OR EXTENDABLE LEGS . . . standard legs are 12" long to provide a 33" desk high working height. The legs may be removed for table or other mounting . . . or extended to fit individual needs.

7. TORQUE ARM ADJUSTING NUT . . . permits exterior adjustment of V-Belt. An inspection plate (at rear) may be removed for visual adjustment or replacement of belt.

8. CRIB AND MULLER SCRAPERS . . . assures ease of cleaning, no "build up" of material, and are vital to many specialized mixing jobs. Integral design of crib, turret and bedplates also provides quicker, easier cleaning.

THE laboratory mortar and pestle has long been the world's "number one" method for establishing mixing standards and checking quality and efficiency. Your *modern* "mortar and pestle" is the new Simpson LF MIX-MULLER . . . with a special pair of revolving mullers and plows to provide the rubbing and smearing action that so thoroughly blends components into a uniform, inseparable mass.

Manufactured to the same exacting standards as the full line of larger Simpson MIX-MULLERS, the 24" pan diameter LF has all components—mullers, turret, crib, etc. . . . including batch capacity—scaled down proportionately. It provides a simple, extremely accurate working duplication of production mixing, for both laboratory and pilot plant service.

Bring modern "mortar and pestle" accuracy to your laboratory mixing. Consult a National engineer today.

Write for Bulletin 515.

SIMPSON *MIX-MULLER*® DIVISION

NATIONAL ENGINEERING CO., 604 Machinery Hall Bldg., Chicago 6, Ill.
(Not Inc.)


If you want freedom from worry,
install
POWELL VALVES
Fig. 1793
Large 125-pound Iron Body Bronze Mounted Gate Valve for oil, water, gas and low pressure steam services. Sizes 2" to 30", incl. Also available in All Iron (Fig. 1816)
It may not be one of the "Four Freedoms" but freedom from worry is greatly to be desired. In flow control equipment you can have this freedom with Powell Valves—the valves with a record for long, dependable performance with minimum maintenance.
The Wm. Powell Company
Cincinnati 22, Ohio
POWELL

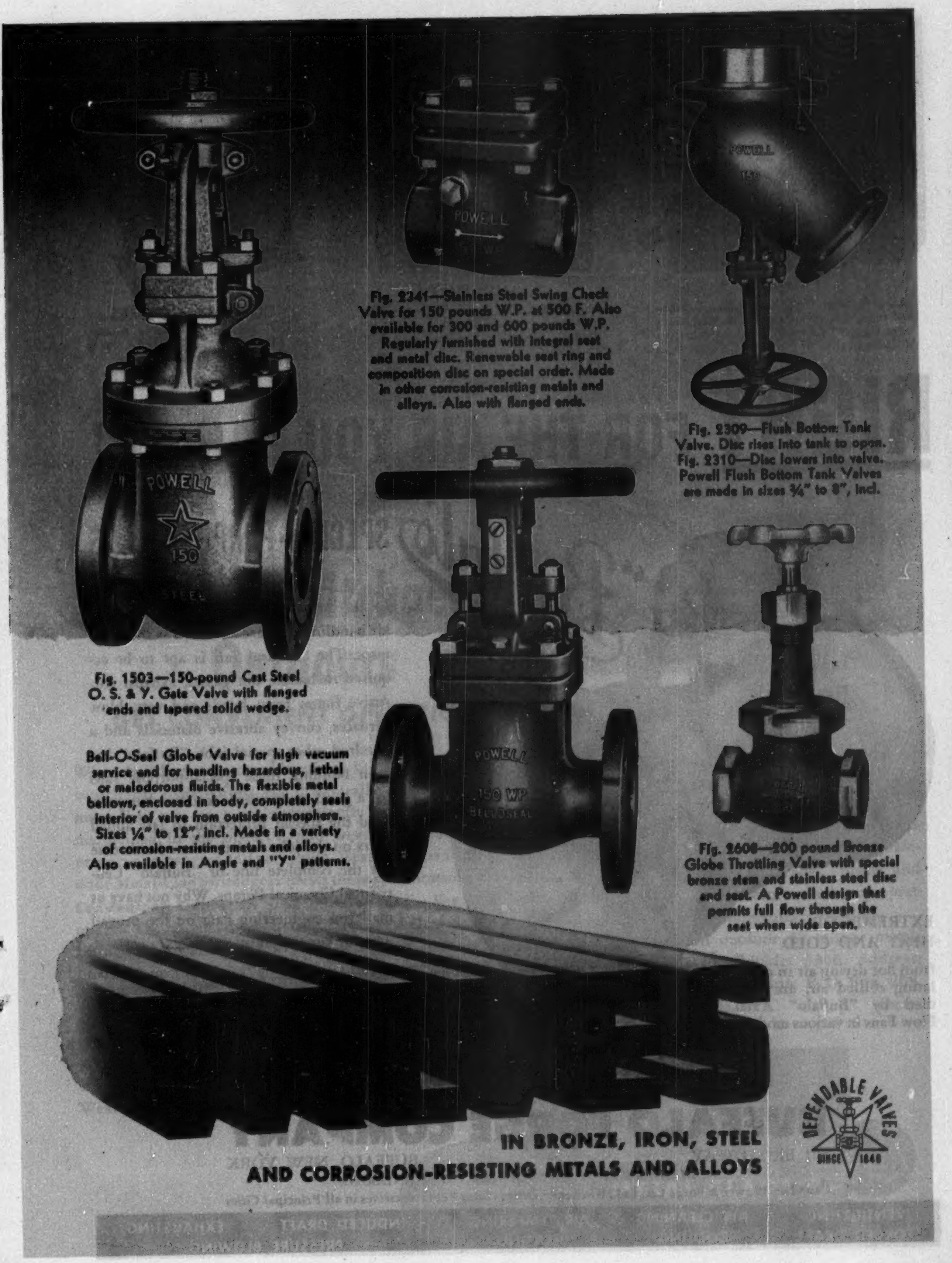
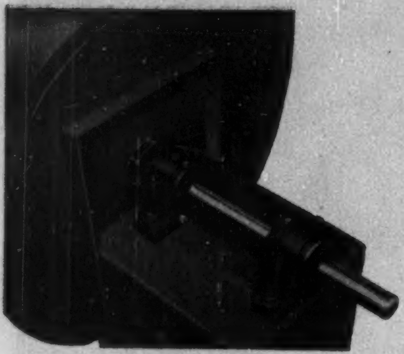
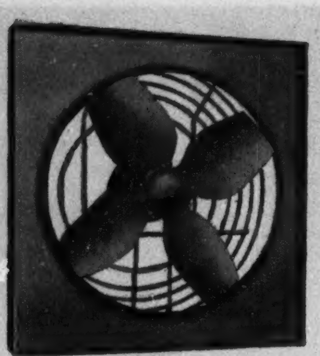


Fig. 2341—Stainless Steel Swing Check Valve for 150 pounds W.P. at 500 F. Also available for 300 and 600 pounds W.P. Regularly furnished with integral seat and metal disc. Renewable seat ring and composition disc on special order. Made in other corrosion-resisting metals and alloys. Also with flanged ends.
Fig. 2309—Flush Bottom Tank Valve. Disc rises into tank to open. Fig. 2310—Disc lowers into valve. Powell Flush Bottom Tank Valves are made in sizes ¾" to 8", incl.
Fig. 1503—150-pound Cast Steel O. S. & Y. Gate Valve with flanged ends and tapered solid wedge.
Bell-O-Seal Globe Valve for high vacuum service and for handling hazardous, lethal or malodorous fluids. The flexible metal bellows, enclosed in body, completely seals interior of valve from outside atmosphere. Sizes ¼" to 12", incl. Made in a variety of corrosion-resisting metals and alloys. Also available in Angle and "Y" patterns.
Fig. 2608—200 pound Bronze Globe Throttling Valve with special bronze stem and stainless steel disc and seat. A Powell design that permits full flow through the seat when wide open.
IN BRONZE, IRON, STEEL
AND CORROSION-RESISTING METALS AND ALLOYS
DEPENDABLE VALVES
SINCE 1846
POWELL
150
STEEL
150 WP
BELLOSEAL



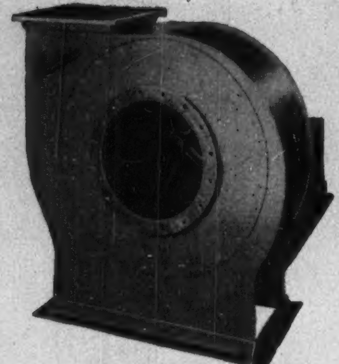
1. HEAT

One of several types of "Buffalo" high-heat fans, this Industrial Exhauster has a "heat slinger" or small external rotor, to dissipate heat.



2. MOISTURE

and/or heat and corrosion are conditions under which special models of "Buffalo" Propeller Fans are operating satisfactorily.

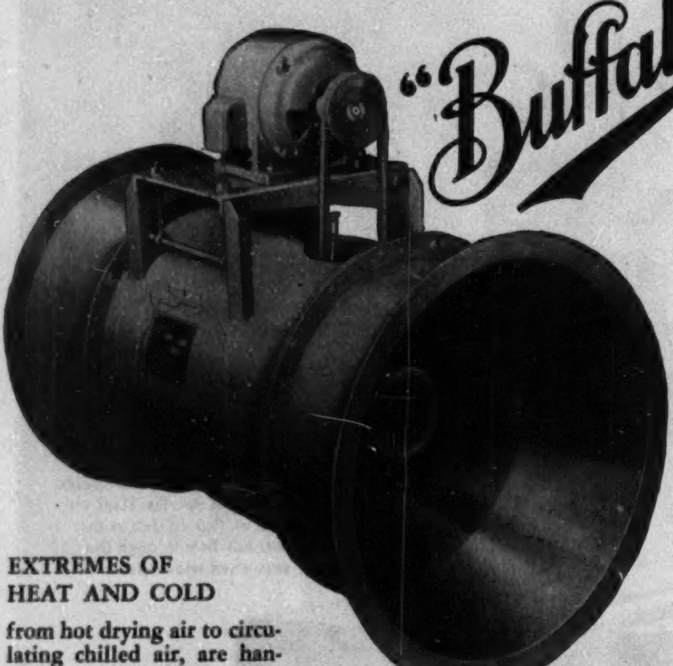


3. CORROSIVE FUMES

"Buffalo" Fans are available rubber-lined, like the exhauster above, or in stainless steel or special coatings.

RIGHT FOR THE AIR YOU HANDLE!

"Buffalo" SPECIAL-PURPOSE FANS



EXTREMES OF HEAT AND COLD

from hot drying air to circulating chilled air, are handled by "Buffalo" Axial Flow Fans in various models.

In the present-day chemical installation, air handling jobs are as varied as the processes. The chemical fan is apt to be required to handle hot gasses, exhaust corrosive fumes from hoods and vats, blow furnaces, convey abrasive materials and a hundred other special jobs. "Buffalo" has been building these special-purpose fans for a good many years—knows what parts need the special protection to last added years on the job. And the same holds true for the complete line of "Buffalo" Centrifugal Chemical Pumps. Why not have us mail you engineering data on the proved unit for your application?

"Buffalo" FIRST FOR FANS

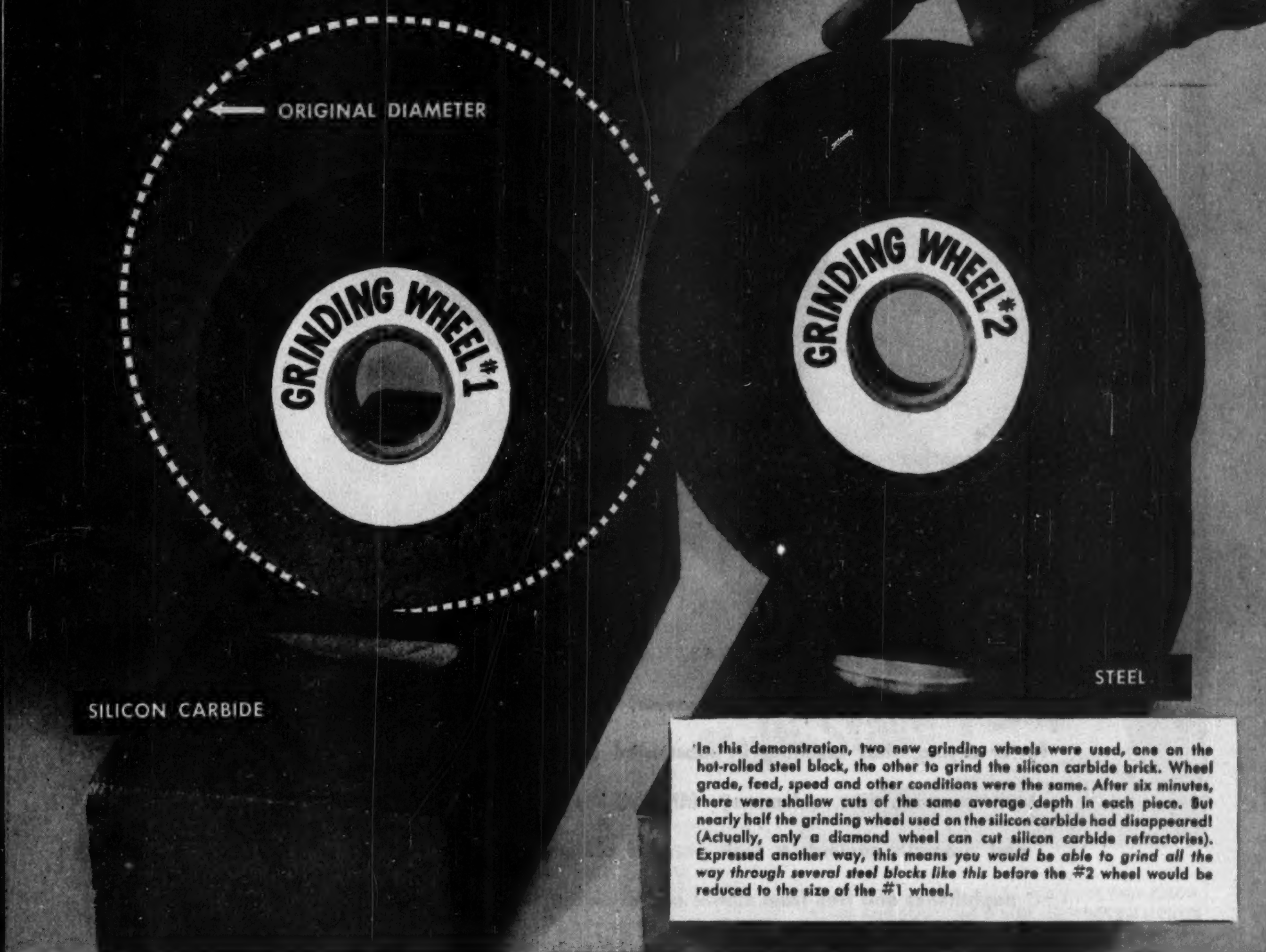
BUFFALO FORGE COMPANY

501 BROADWAY BUFFALO, NEW YORK

PUBLISHERS OF "FAN ENGINEERING" HANDBOOK

Canadian Blower & Forge Co., Ltd., Kitchener, Ont. Sales Representatives in all Principal Cities

VENTILATING AIR CLEANING AIR TEMPERING INDUCED DRAFT EXHAUSTING
FORCED DRAFT COOLING HEATING PRESSURE BLOWING



In this demonstration, two new grinding wheels were used, one on the hot-rolled steel block, the other to grind the silicon carbide brick. Wheel grade, feed, speed and other conditions were the same. After six minutes, there were shallow cuts of the same average depth in each piece. But nearly half the grinding wheel used on the silicon carbide had disappeared! (Actually, only a diamond wheel can cut silicon carbide refractories). Expressed another way, this means *you would be able to grind all the way through several steel blocks like this before the #2 wheel would be reduced to the size of the #1 wheel.*

harder than steel, more abrasion-resistant than paving blocks—silicon carbide is...

so hard it wears out grinding wheels

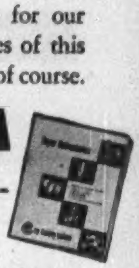
As hard as steel is, it can't compare with our silicon carbide refractories (trademarked CARBOFRAX®). Used under the toughest abrasion conditions known, these refractories have repeatedly proved able to outwear other normally durable lining materials. *This applies to room-temperature applications as well as to others ranging up to 3000 F, or more.* It applies to abrasion caused by rubbing or sliding, and to abrasion caused by impingement of sharp particles traveling at high velocities.

For example: In cyclone dust collectors where there is a constant blast of highly abrasive particles . . . in coke chutes and hoppers that must withstand punishing cascades of sharp-edged coke . . . in hot blast mains where abrasive dust is entrained in high-velocity gases . . . in billet heating furnaces where metal slabs are dragged across the floor. In short, wherever other materials need replacement so often as to make their use uneconomical.

Have you any spots like these; areas highly vulnerable to abrasion? Then check on these CARBOFRAX refractories. Available as tile, brick or special, close-tolerance shapes, these materials can give your equipment "armor-plate" protection. They are particularly valuable where heat or chemical action may be teamed with abrasion. Write for our booklet that describes all the interesting properties of this and other unique super refractories. No obligation, of course.

CARBORUNDUM

Registered Trade Mark



Dept. H-63, Refractories Division
The Carborundum Company, Perth Amboy, N. J.
Send complimentary copy of Super Refractories booklet to:

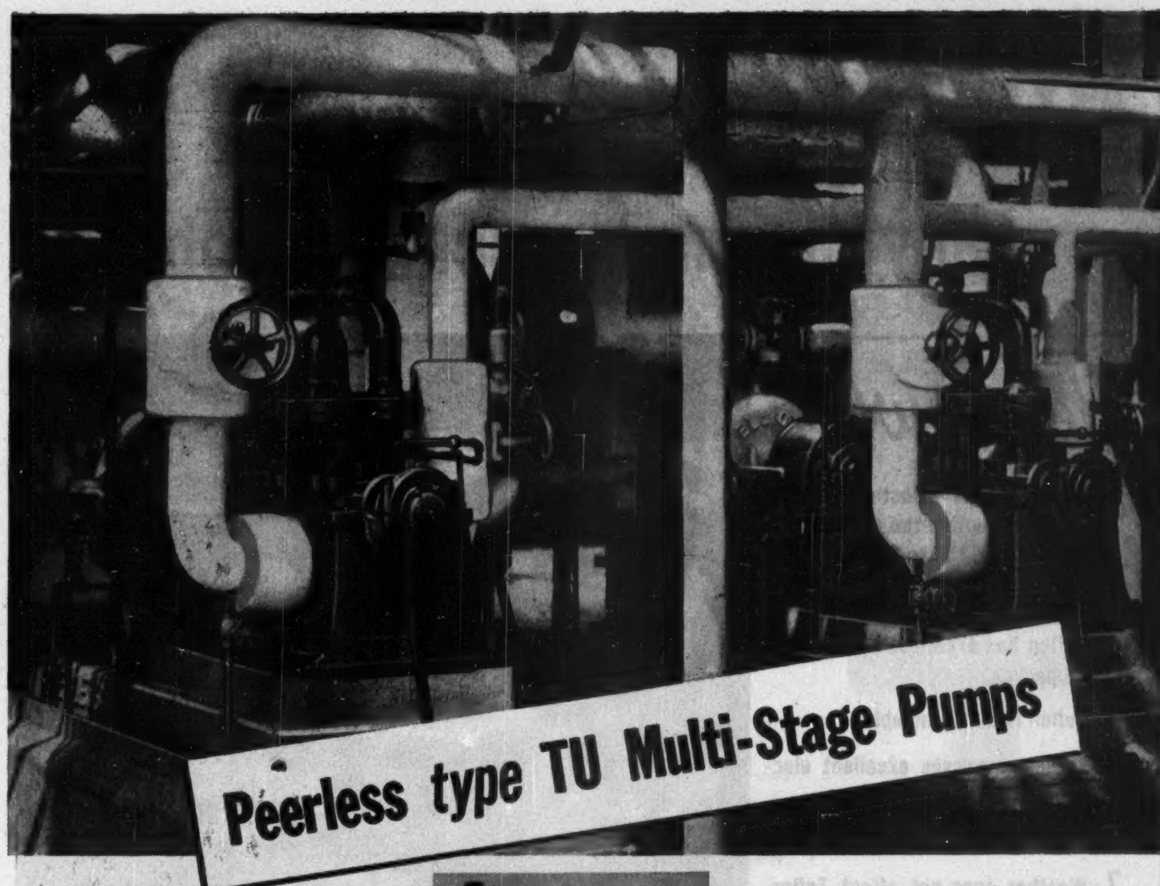
NAME____________________

POSITION____________________

COMPANY____________________

STREET____________________

CITY__________ ZONE______ STATE______



PEERLESS PUMPS

4 COST-SAVING FEATURES OF THE TYPE TU LINE

- *SIMPLICITY IN DESIGN*
- *GOOD HYDRAULIC CHARACTERISTICS*
- *DURABLE, RUGGED CONSTRUCTION*
- *ON-THE-JOB DEPENDABILITY*

2, 3, 4 AND 5-STAGE PUMPS FOR SUPPLYING CIRCULATING AND BOOSTING WATER AND PROCESS LIQUIDS AGAINST MEDIUM AND HIGH HEADS. Put these dependable pumps to work for you. They'll deliver high maintained efficiencies over an extended service life. Their split-case design makes them easy to service and maintain. Their precision construction guarantees year after year durability. In all sizes 4" and under, cross over between stages is built integral with upper pump case. Over-size shafts, wear rings, shaft sleeves, heavy duty ball bearings, modern case and impeller design are outstanding features. Choose from many types and sizes for all head and capacity requirements.

PROFUSELY ILLUSTRATED BULLETIN. A new 4-color bulletin describes the Peerless Type TU pumps. It's complete with pump cross-section, dimensional drawings and load-capacity data. Use coupon below.

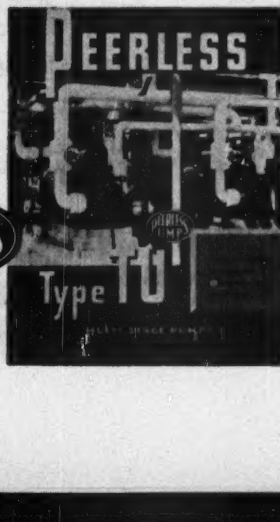
GENERAL SPECIFICATIONS

HEADS	Up to 1600 Feet
CAPACITIES	Up to 3000 GPM
TEMPERATURES	Up to 300°F
CASE PRESSURES	Up to 800 Lbs.
HP RANGE	Up to 325 BHP
DRIVES	All Types
CONSTRUCTION	Cast Iron, Bronze, Stainless

PEERLESS PUMP DIVISION

FOOD MACHINERY AND CHEMICAL CORPORATION

Address inquiries to Factories at: Los Angeles 31, Calif. & Indianapolis, Ind. Offices: New York; Chicago; Indianapolis; St. Louis; Atlanta; Tulsa; Plainview and Lubbock, Texas; Fresno; Los Angeles; Phoenix; Albuquerque, New Mexico. Distributors in Principal Cities; Consult your Telephone Directory



MAIL COUPON FOR NEW BULLETIN

PEERLESS PUMP DIVISION
Food Machinery and Chemical Corporation
301 West Avenue 26, Los Angeles 31, California

Please send a copy of TU Pump Bulletin No. B-1400 to:

NAME_______________

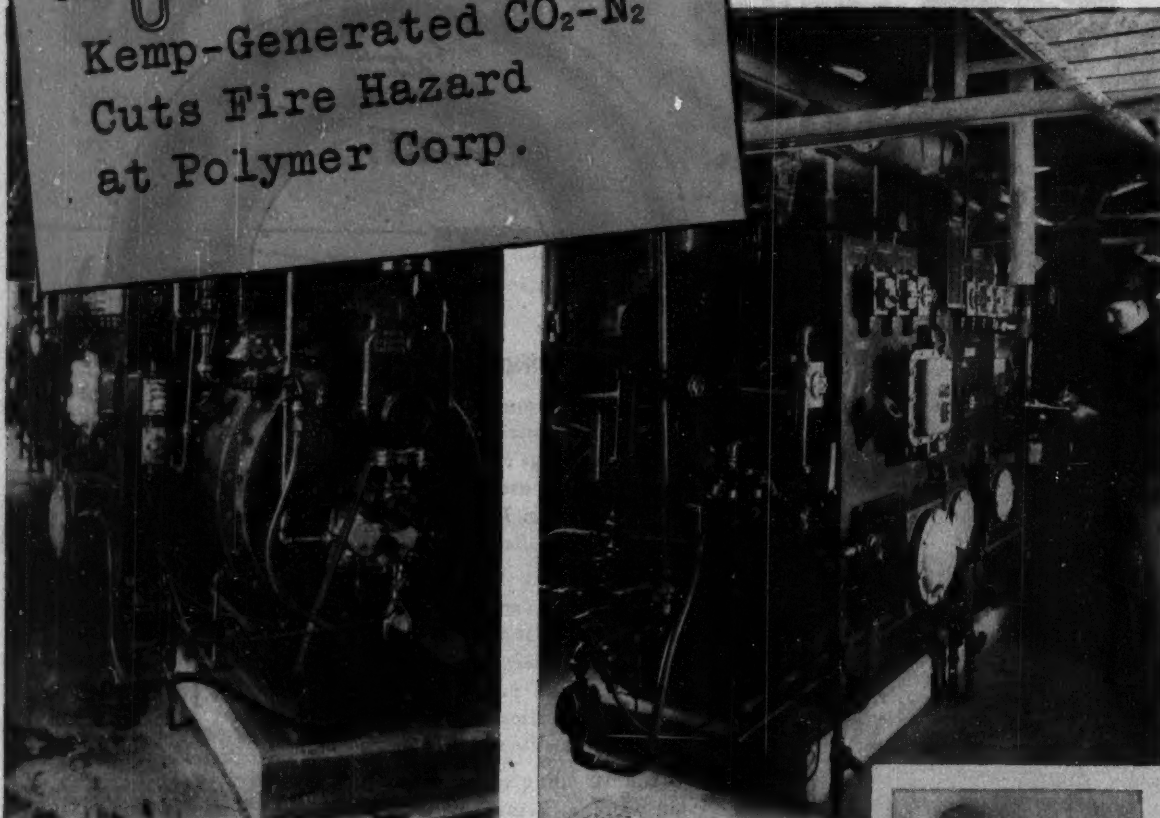
COMPANY_______________

ADDRESS_______________

CITY_______________ STATE_______________

Chem Eng

Case No. 62
Kemp-Generated CO_2-N_2 Cuts Fire Hazard at Polymer Corp.



How Polymer operated day and night for 10 years at maximum safety

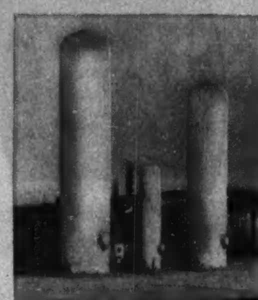
When Polymer Corporation, Ltd., Sarnia, Ontario, began operations in 1943, inventory included two Kemp MIHE Inert Gas Generators. Since that date, Polymer—and its Kemp equipment—has been operating 24 hours a day, 365 days a year. The huge quantities of man-made rubber and associated chemicals it produces—200,000,000 pounds during one year alone—reach, in one form or another, the four corners of the world.

Kemp Plays an Important Role

The high volatility of many of the ingredients used in this giant operation necessitates blanketing and purging vessels after use. It is in this step that Polymer employs Kemp Generators to assure safe, trouble-free performance. The gas they produce is piped to different operations over the entire company area—it *must* be clean! Kemp does the job—Polymer knows that it can depend on Kemp to deliver a *clean inert at a specific analysis, regardless of demand.* And every Kemp Generator is engineered for fast starts and easy operations that save *time* and *money.*

Kemp Can Do a Job for You

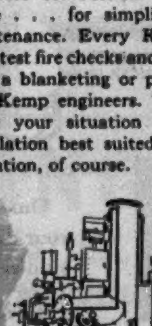
Kemp superiority is no accident. It is based on years of experience . . . on quality of design to meet specific problems. Every Kemp design features the Kemp Industrial Carburetor for complete combustion without tinkering or waste . . . for simplified installation and maintenance. Every Kemp design includes the latest fire checks and safety devices. If you have a blanketing or purging problem, contact Kemp engineers. They will be glad to study your situation and recommend the installation best suited to your needs. No obligation, of course.



Gas generator building from which inert gas is piped over 130 acres of company property at Polymer's Sarnia, Ontario, operation.

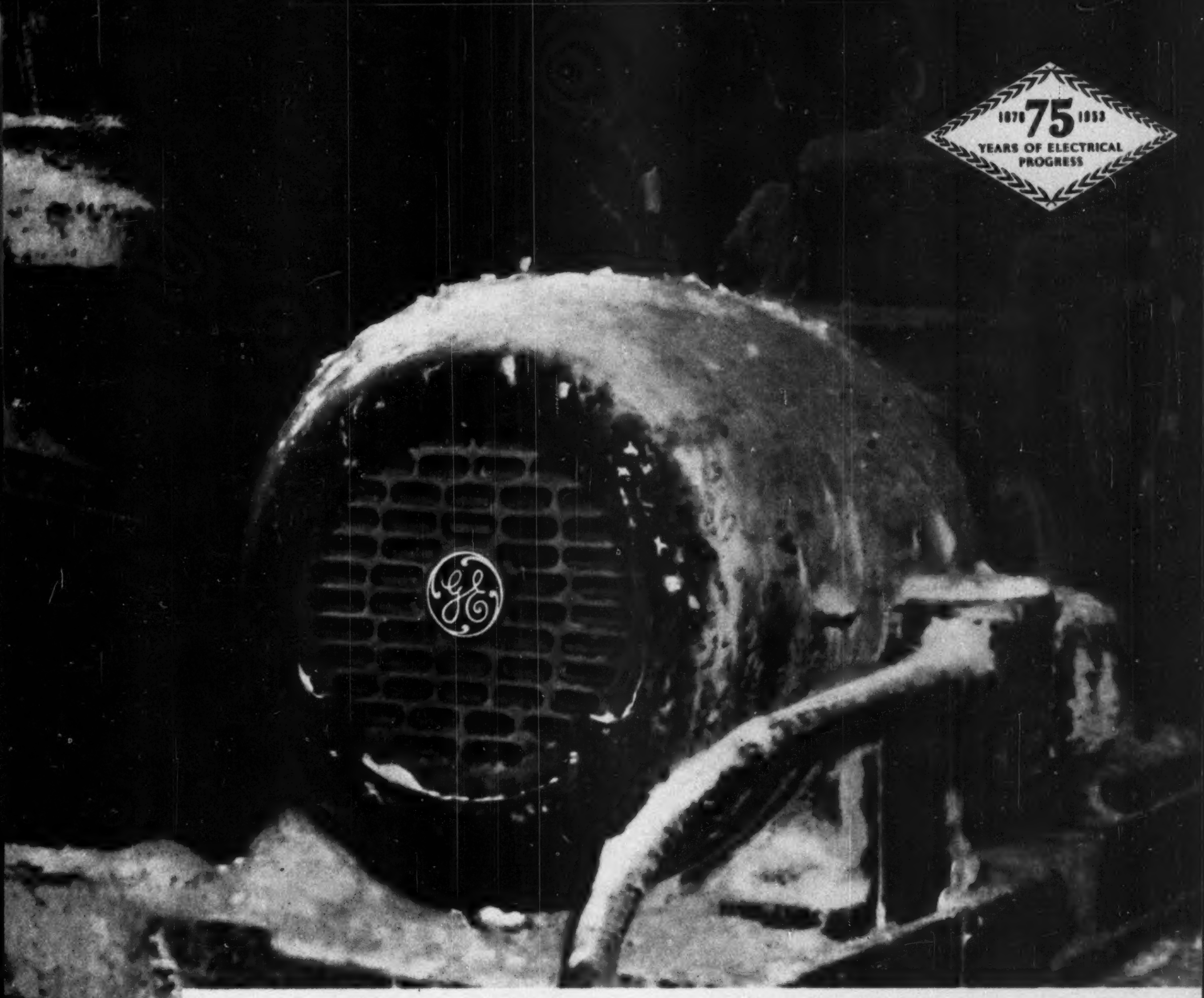
***For more complete facts and technical information, write for Bulletin I-10 to:* THE C. M. KEMP MFG. CO., 405 East Oliver Street, Baltimore 2, Md.**

KEMP OF BALTIMORE



INERT GAS GENERATORS

CARBURETORS • BURNERS • FIRE CHECKS
METAL MELTING UNITS • ADSORPTIVE DRYERS
SINGEING EQUIPMENT



Corrosion won't hurt this TRI-CLAD motor's cast-iron frame

REG. U.S. PAT. OFF.

HERE'S A COMMON SIGHT AROUND MANY PLANTS— A G-E Tri-Clad motor operating reliably and continuously under the extremely corrosive conditions that cause many other motors to fail.

THAT'S WHY YOU CAN EXPECT superior performance from G-E Tri-Clad motors. Consider these facts:

CORROSION-RESISTANT CAST-IRON means longer motor life. Unlike steel, cast-iron resists corrosive pitting, even when the paint is chipped.

RIGID, CAST STATOR FRAME with integrally cast feet, can't be twisted out of line by accidental jarring or by excessive "bolt-down" pressure on the feet.

STRONG, CAST-IRON END SHIELDS have cast ribs for extra strength without adding extra weight . . . protect the true motor alignment even under heavy shaft loads.

ORDER G-E TRI-CLAD MOTORS from your nearby G-E Apparatus Sales Office or G-E Agent or distributor. General Electric Co., Schenectady 5, N. Y. 752-19

You can put your confidence in—

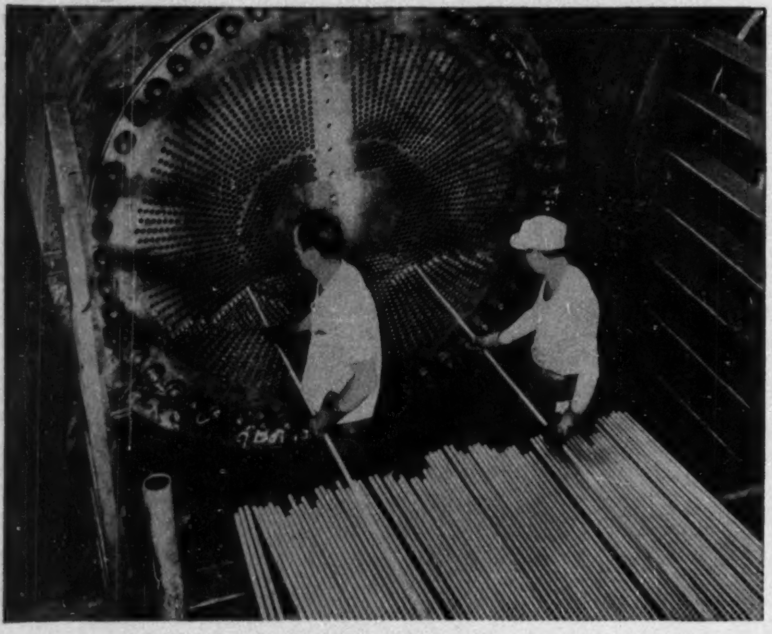
GENERAL ELECTRIC

BRIDGEPORT BRASS COMPANY

CONDENSER AND HEAT EXCHANGER TUBE EDITION

COPPER ALLOY BULLETIN

Bridgeport Brass Co. — MILLS IN BRIDGEPORT, CONN. AND INDIANAPOLIS, IND.—IN CANADA: NORANDA COPPER AND BRASS LIMITED, MONTREAL



Operators installing tubes into a Radial-Flow surface condenser—courtesy Westinghouse Electric Corporation.

The Proper Storage of Condenser Tubes

Some plants always carry a stock of tubes in order to make speedy repairs and keep shutdown time to a minimum. The benefits from such forward planning will not be fully realized if some of these tubes become damaged from improper storage.

Also improper handling may result in dents, digs, kinks, or a permanent set which predispose the tubing to premature failure. In the case of dents, water impinging on the bumps inside the tubes may cut through the protective film at that point and thin the wall locally until eventually perforation occurs.

Damp Warehouses Unsatisfactory

Storage in damp warehouses subject to a wide range of temperatures is undesirable. Setting cases of tubes on wet floors or wet ground should be avoided because they absorb and retain moisture. White, green, blue, and black salts and red and black oxides form on tubes in contact with the wet walls of wooden cases. Condensation of moisture leads to surface corrosion and cracking because the condensate remains as a thin film of water for a long period without drying out or evaporating. This film may absorb gases from the atmosphere and may become quite concentrated with time. This corrosive water film has in some instances led to very severe corrosion.

On the other hand, tubes stored in dry, clean, well-aired warehouses will quickly lose the film of condensate, and do not deteriorate although they may darken in color with time.

Effects of Outdoor Storage

Outdoor storage may lead to the accumulation of dust, cinders, and soot which together with rain, snow, and condensation produce serious corrosion on the outside surface and the ends of the tubes. Covering with a tarpaulin should be arranged in the form of a tent with vents at the peak to permit free circulation of air and thereby keep dampness to a minimum. The combined action of high humidity and certain contaminants in the atmosphere, such as ammonia, may produce season cracking especially if the storage period is extended.

Since a certain percentage of tubes may be subject to failure if stored for long periods under unfavorable conditions, trouble may develop if such tubes are used for making emergency repairs. To prevent such an occurrence, some operators make a laboratory examination of stored tubes periodically to determine if they are undergoing serious attack from corrosion or are showing signs of stress corrosion cracking.

Bridgeport recognizes the importance of protecting tubes in handling and in transit. They are carefully packed in wooden cases to arrive in perfect condition. The same care should be used by operators in handling and storing tubes.

Recommendations for Proper Storage

(1) Keep tubes in cases, flat until ready for use—but don't stack too high to avoid crushing of bottom cases.

(2) Select a dry, protected storage location not subject to extremes of humidity and temperature. A hot, dry location is best. If necessary, dehumidify the storage area.

(3) Avoid outdoor storage especially where there is dirt, dampness, smoke, soot and corrosive fumes.

(4) If cases become watersoaked, both the cases and tubes should be dried out promptly.

(5) If stored in racks, tubes should be supported properly.

Bridgeport's laboratory will be glad to help condenser tube users in the selection of alloys to meet existing service conditions. Get in touch with the nearest Bridgeport district office for assistance on your corrosion problems and for your condenser and heat exchanger tube requirements. (9892)

DEPRECIATION
And Its Crucial Economic Role

The sixth annual McGraw-Hill survey of Business' Plans for New Plants and Equipment, just completed, reveals some remarkable facts about the role of depreciation in our economy. To most people, depreciation is a technical term, used by accountants to discuss a dull subject. But it really is a simple matter: It is the amount of money set aside each year by a company to replace plant and equipment that is wearing out. And here are some facts from this survey* which show how depreciation can make the difference between prosperity and recession in the United States:

1. *In 1953, about half of all the money spent on new manufacturing plants and equipment will come from depreciation reserves.* For the future, manufacturing companies are relying even more heavily on this source of money. In the years 1954-56, they count on using their depreciation funds to pay for almost two-thirds of the new plants and equipment now planned.

2. *The amounts of money made available by depreciation allowances vary greatly from industry to industry.* Some industries, such as those producing steel, chemicals and petroleum products, will have relatively large amounts of cash available from their depreciation reserves. In considerable measure, this is because the government is allowing them to accumulate such reserves at an accelerated rate as an encouragement to build facilities required for national defense. But most of the companies engaged in the production of textiles, processed foods and many kinds of machinery have had little chance to benefit by this provision for accelerated depreciation. Hence, they have much less money available from depreciation reserves.

3. *There is a definite shortage of investment funds in the industries that have relatively low depreciation allowances.* Taken together, the coal mining, textile, food processing, machinery and other metal-fabricating industries plan to spend about $4.7 billion for new plant and equipment this year. But they report that they would spend $1.5 billion *more* per year during the period 1954-56 if sufficient funds were available.

4. *Eighty-five per cent of the manufacturing companies covered by the survey reported that they plan to invest all their depreciation funds* to keep equipment up-to-date and to provide capacity for new products and new markets. These companies could let their depreciation funds pile up as idle cash. But the intention is to spend most of them for capital equipment.

*The sixth annual McGraw-Hill survey of Business' Plans for New Plants and Equipment included companies that provide 25 per cent of all industrial employment and 60 per cent of employment in those industries where capital investment is highest. These companies are mostly the larger companies in their respective industries. A copy of the full report of this survey can be obtained by addressing: Department of Economics, McGraw-Hill Publishing Company, Inc., 330 West 42nd St., New York 36, N. Y.

Hence, there is a direct relationship between the amount of depreciation funds available and the level of capital investment. And it is upon the latter that the level of general prosperity decisively depends. One-third of all industrial workers are engaged in producing or installing such equipment.

This fact that the level of depreciation allowances has a major bearing on the level of capital investment should not surprise anyone. In several foreign countries where these allowances have been increased, investment has boomed. The two nations with the highest ratios of investment to national income are Canada and Norway. Both countries adopted flexible depreciation policies after World War II. In Sweden and The Netherlands also, flexible depreciation allowances have contributed to rapid industrial expansion. Finally, the tremendous investment brought about by our own rapid amortization program shows dramatically the importance of depreciation in stimulating capital expenditures.

Obsolete Tax Laws

In spite of this record, the fact remains that our laws and the business procedures that govern depreciation allowances — in particular the laws and rulings that govern the deduction of depreciation from taxable corporate income — are still based on antique and obsolete accounting concepts which take no account of depreciation's dynamic role in our economy. The internal revenue code still requires most companies to depreciate their equipment over a long period, even though these small annual allowances cannot possibly pay for the investment that is necessary to keep a plant up-to-date under today's rapidly changing technology, with its production of new and improved machinery.

The only allowance made by the government for rapid depreciation is that which is authorized for certain types of plants during the defense emergency. Under this policy most companies are unable to use accelerated depreciation for tax purposes. And as defense projects are completed, the number of new authorizations is dropping. We may lose the chance to utilize fully this powerful tool for sustaining investment because, under our ramshackle emergency tax structure, accelerated depreciation is available only to a minority of firms on a temporary basis.

New Policy Needed

A sensible, up-to-date depreciation policy for tax purposes is long overdue. Either the Treasury must modernize the internal revenue code on its own initiative, or Congress must take the lead by writing into permanent law a flexible depreciation policy applicable to all companies.

Treasury experts now have before them a number of proposals to allow faster depreciation for the average firm. The U.S. Chamber of Commerce has suggested that companies be allowed to deduct from taxable income 25 per cent of the cost of new equipment in the first year, with the remaining cost to be deductible over the life of the facilities. The Machinery and Allied Products Institute has long sponsored a formula that would allow full deduction in two-thirds of the estimated life of the property. In Congress, Chairman Reed of the Joint Committee on Internal Revenue Taxation has stated that we need a more flexible depreciation policy. Senator Frear of Delaware has introduced a bill that would let a business make its own choice on how fast to depreciate its equipment.

It will take time and study to determine which of these various proposals best fits the needs of the economy without sacrificing unduly the revenue needs of the government. If we are to have a new depreciation policy, designed for a long period ahead, it must be carefully worked out. But this much is clear right now: *The development of a flexible depreciation policy on the part of the federal tax authorities is one of the most important steps that can be taken to sustain prosperity. When we talk about depreciation, we are talking about the money that pays for almost two-thirds of the new manufacturing facilities now scheduled for construction. We are talking about the new investment and the new jobs on which our continued prosperity depends.*

McGraw-Hill Publishing Company, Inc.

HERE'S WHAT CAN HAPPEN when you overload your control equipment beyond its maximum interrupting capacity. Luckily this was a test under regulated conditions . . . but this (inset) is what could happen to your equipment with inadequate interrupting capacity in your control.

Protect your costly equipment with High Voltage G-E Limitamp Control

interrupting capacity up to 250,000 kva

Don't take chances on inadequate interrupting capacity. Be sure you have the right controls to protect your equipment and personnel against the possibility of sudden and destructive electrical overloads.

For complete protection against short-circuit conditions up to 250,000 kva specify G-E Limitamp Control, a high voltage motor starter (to 4800 volts) for motors up to 2250 hp.

G-E Limitamp is easy to maintain, simple to operate. Parts can be inspected at a glance . . . fuses are easily accessible in a protected compartment . . . push-button operation permits manual starting and stopping . . . equipment stands up for years under tough conditions.

G-E engineers study your requirements . . . design all components into a co-ordinated "package" that will give you adequate interrupting capacity for your system.

For complete information contact your nearest G-E representative or write for Bulletin GEA-5409A, General Electric Company, Section 781-4, Schenectady 5,. New York.

G-E Limitamp Control

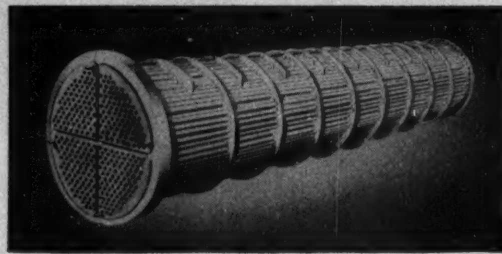
You can put your confidence in—

GENERAL ELECTRIC

Cut cost and corrosion in the process with

ALCOA ALUMINUM

- Heat Exchanger Tubes
- Pipe
- Storage Tanks
- Tank Cars



ALCOA ALUMINUM HEAT EXCHANGER TUBES

Check these BIG Heat Exchanger Tube savings:

Fabrication . . . Their ductility makes them easy to roll in and bend.

Shipping and handling . . . Completed bundles weigh far less than bundles of heavy metal tubes.

Cleaning . . . Require far less cleaning than Admiralty tubes in furfural service. Aluminum does not catalytically polymerize furfural.

Low Temperature Service . . . Strength actually increases as temperatures drop to –320° F and below.

Original Cost . . . Alcoa Aluminum Tubes cost 1/2 less than Admiralty, 1/3 less than Mild Steel, 1/5 as much as Stainless. An average-sized refinery can save $50,000 in first cost by using Alcoa Aluminum Tubes (figured on 20,000 tubes) as this chart shows:

PRICE PER 16 FOOT LONG TUBE

	⅝" O.D.x .049" wall	¾" O.D.x .049" wall	¾" O.D.x .065" wall	1" O.D.x .065" wall
3S-H14	$1.17	$1.33	$1.62	$2.09
Alclad 3S-H14	1.49	1.73	2.04	2.69
Seamless Mild Steel	2.68	2.82	3.18	3.49
Admiralty Brass	2.95	3.53	4.39	6.10
Cupro Nickel (30%)	4.42	5.30	6.78	9.19
Stainless Steel (304)	8.61	9.67	11.38	13.73

Note: All prices are approximate. Prices for 3S-H14 and Alclad 3S-H14 based on lots of 2000-4999 lbs., for Admiralty and Cupro Nickel 5000 to 9999 lbs. Prices for Mild Steel and Stainless based on lots of 10,000 ft. with exception of size 1" O.D. x .065" wall which is based on 5000 ft.

Use Alcoa Alclad 3S-H14 Heat Exchanger Tubes with fresh, brackish and salt cooling waters.

Check These Heat Exchanger Tube Uses:

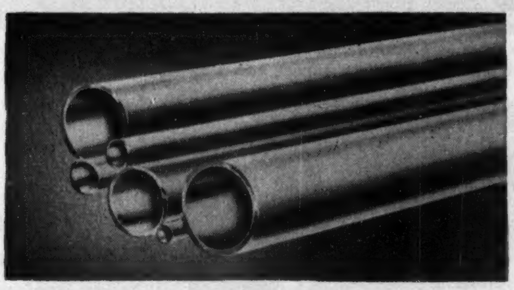
PETROLEUM

Amine solution coolers	Jacket water coolers
Condensers handling hydrocarbon fractions from such processes as Thermal and Catalytic cracking, reforming, polymerizing, etc.	Lean oil—rich oil exchangers
Furfural condensers and heat exchangers	Lube oil coolers
Glycol-amine heat exchangers and reboilers	Natural gas compressor aftercoolers
Hydrogen sulfide gas coolers	Propane chilling
	Recompressor aftercoolers
	Vapor recovery condensers
	Wax sweaters

CHEMICAL

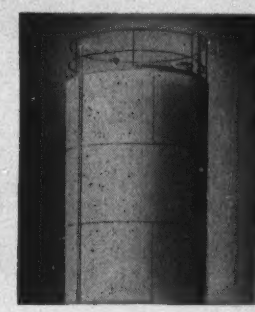
Acetaldehyde	Hydrogen Cyanide
Acetanilide	Hydrogen Peroxide
Acetic acid	Isopropanol
Ammonia	Methanol
Benzene	Naphtha
Butanol	Nitric acid (concentrated)
Butyric acid	Phenol
Dichlorobenzene	Propylene Glycol
Ethanol	Pyridine
Ethylene Glycol	Ricinoleic acid
Formaldehyde	Stearic, Palmitic, Maleic Oleic acids
Furfural	Turpentine
Gelatin	Xylene
Glycerin	and many others
Hydroabietyl alcohol	

Alcoa pioneered aluminum heat exchanger tubes 44 years ago. Write for details and the booklet: *Alcoa Aluminum Heat Exchanger Tubes.*



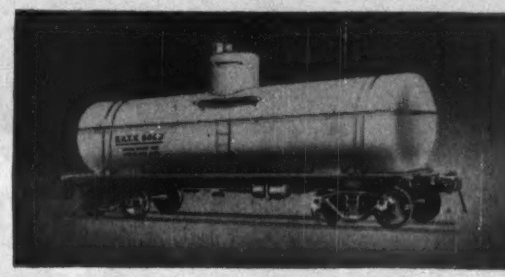
ALCOA ALUMINUM PIPE

Aluminum, of course, is highly resistant to attack by sour crude and most sulphur compounds . . . protects the quality of high-grade resin and other naval stores. It can be joined by every fusion process . . . is easier to handle and install because it weighs 1/3 as much as other materials. Its chemical inertness and corrosion resistance avoid batch and process contamination. High thermal conductivity and ductility speed filling of vessels with cold liquids. You get all these cost-cutting qualities when you use Alcoa Pipe in the processing field. Write for the booklet: *Alcoa Aluminum Pipe.*



ALCOA ALUMINUM STORAGE TANKS

For over 20 years Alcoa Aluminum has been in continuous service handling fatty acids in storage tanks. Aluminum protects the stability and color of essential oils, edible oils, fats, glycerine . . . resists the corrosive effects of sulphur . . . does not stain or discolor products handled . . . is nontoxic . . . inert to many chemicals . . . nonsparking. Write for the pamphlet: *Alcoa Aluminum in the Process Industries.*



ALCOA ALUMINUM TANK CARS

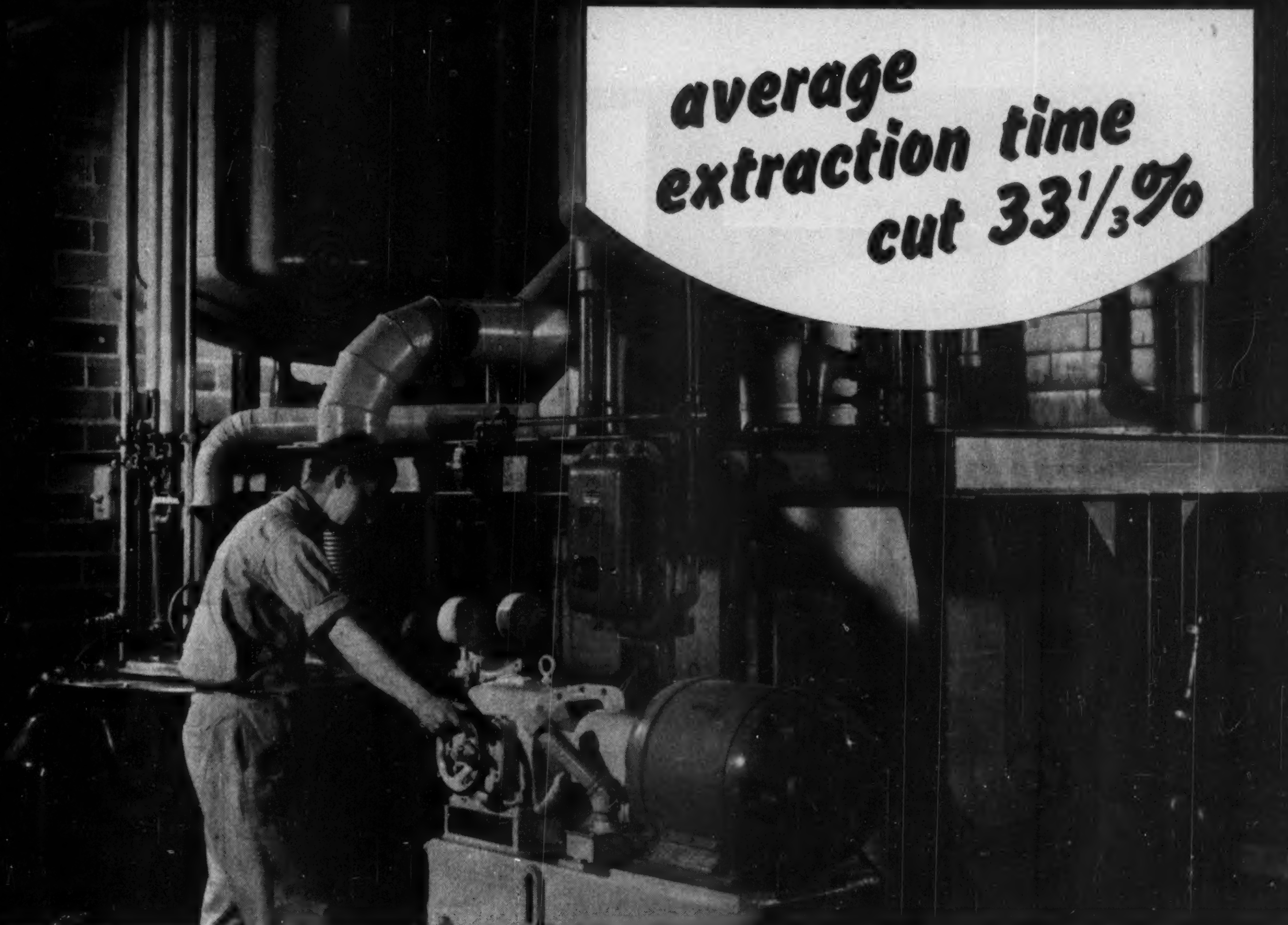
The first tank car of Alcoa Aluminum, in service since 1928, still hauls fatty acids . . . proof that aluminum resists corrosion, gives lasting service, doesn't contaminate its cargo. Leading shippers everywhere report: No damage to ladings . . . no damage to cars, when valuable liquids are delivered in Alcoa Aluminum Tank Cars. Ask your car builder about the advantages of lightweight aluminum rolling stock, or write to Alcoa.

ALUMINUM COMPANY OF AMERICA
900-F Alcoa Building, Pittsburgh 19, Pa.

For process chemicals—catalysts, catalyst carriers and desiccants—investigate ALCOA Chemicals

Alcoa Aluminum

ALUMINUM COMPANY OF AMERICA



Once more the ANY-SPEED Oilgear Drive betters machine performance "painlessly"

Many times in our experience the performance of an already highly efficient machine has been bettered without redesign, solely by changing the drive. One case out of many *varied* cases, is the Tolhurst Centrifugal pictured above, located in a great pharmaceutical house. This centrifugal was originally equipped with a two-speed electric motor drive. However the chemicals it is called upon to handle have widely varying crystal packing characteristics. Some of these crystals packed so densely at the speed available, extraction was inhibited, extraction time far out of balance and crystal removal difficult.

A change was made to an *"ANY-SPEED"* Oilgear Fluid Power Drive. Now the operator is able to shade the speed of the centrifuge experimentally—*and easily discover* the *best* speed for each batch of crystals.

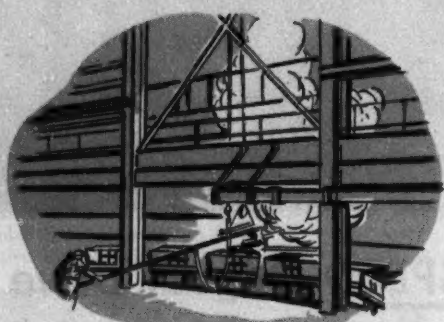
As a result, extracting that used to take from 6 to 9 hours was cut to 4 to 6 hours. The extremely slow speed also available made unloading a great deal easier. This user now has several other Oilgear drives including one on a laboratory centrifuge.

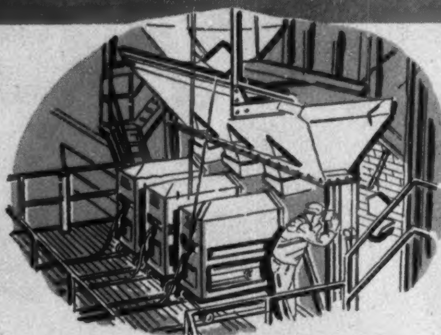
There is very often a direct efficiency coefficient between machine operating speed and the type of work being handled. And we can cite many widely varying instances where equally dramatic and profitable gains resulted at once from a simple change to *"ANY-SPEED"* Oilgear Fluid Power Drives. If you want some interesting factual data on Oilgear's steplessly variable speed drives, their outstanding responsiveness to control impulses, their smooth acceleration and deceleration, talk to an Oilgear Engineering Representative. His mature and sound engineering recommendations may profit you greatly. THE OILGEAR COMPANY, 1579 W. Pierce St., Milwaukee 4, Wisconsin.

OILGEAR

Furnace Refractories

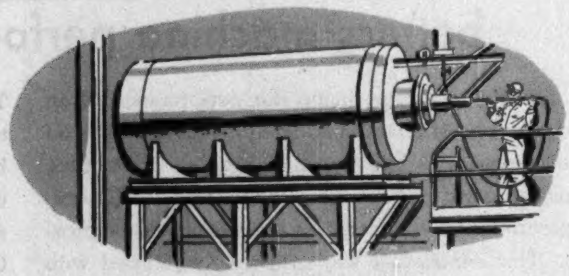
CALCIUM CARBIDE FURNACE

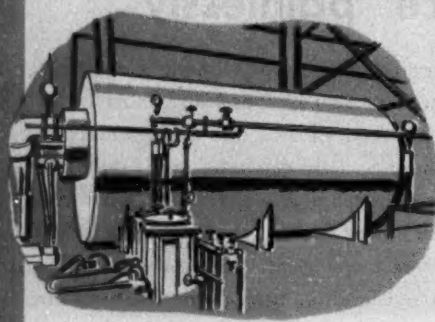




GLASS MELTING FURNACE

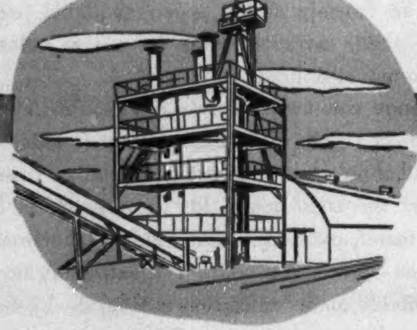
ANHYDROUS HCL FURNACE





SULPHUR BURNER

ROASTER FURNACE

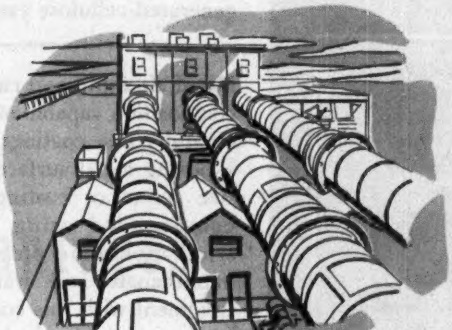


HARBISON- THE WORLD'S Most Complete REFRACTORIES SERVICE WALKER

for longer life and continuous performance

Many chemical processing operations are *tough* on refractories. High temperatures, spalling conditions, abrasive action and chemical attack combine their individual destructive factors to impose exceptionally severe treatment on refractory linings in kilns, roasters and other types of furnaces.

To meet the wide variety of conditions that exist in chemical processing applications, Harbison-Walker offers a complete line of refractories from which can be selected the exact types and brands needed for longest life and most economical service in every part of the furnace. Our Technical Service Department will be glad to make specific recommendations for your requirements.



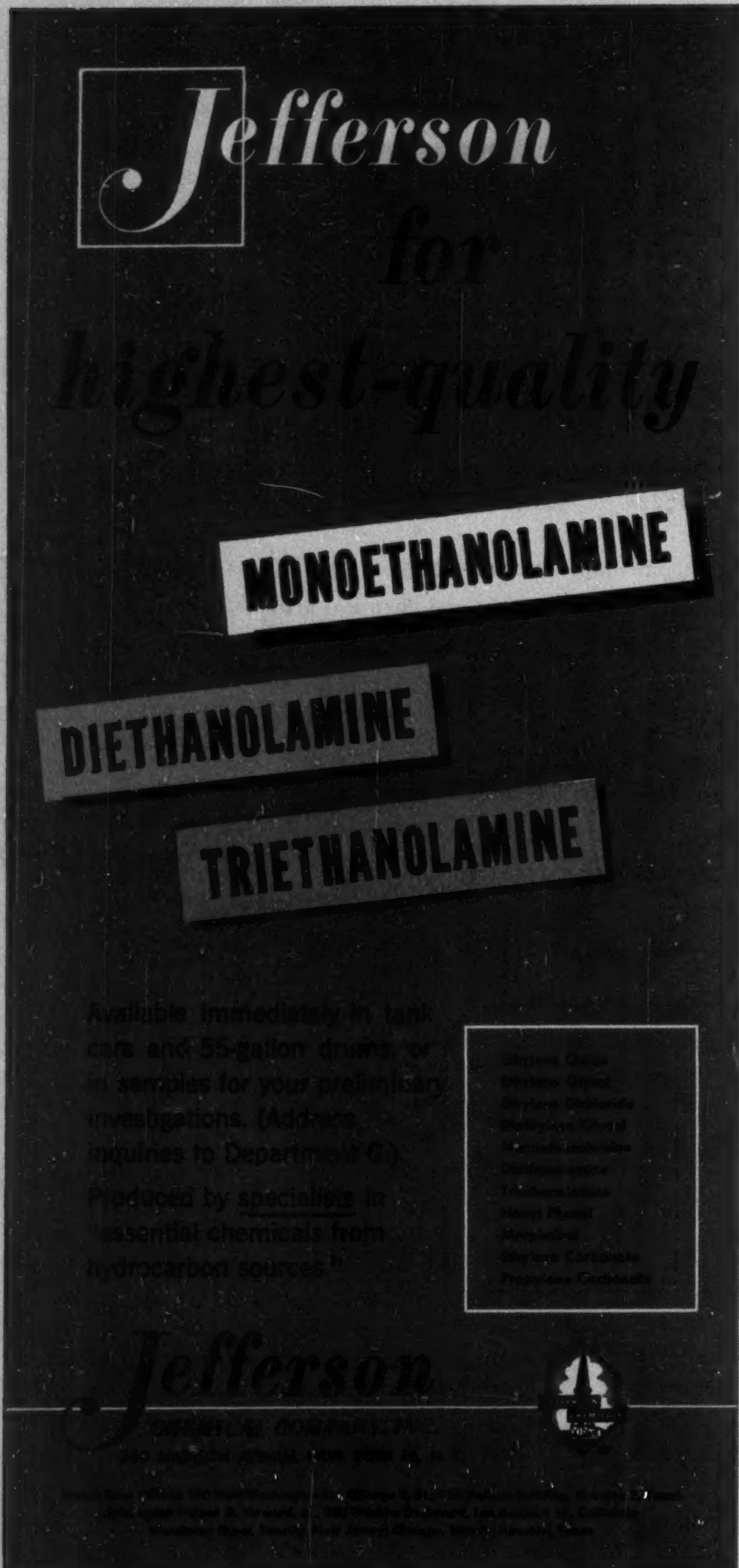
ROTARY KILNS

HARBISON-WALKER REFRACTORIES CO.

AND SUBSIDIARIES

WORLD'S LARGEST PRODUCER OF REFRACTORIES

General Offices . . . Pittsburgh 22, Pennsylvania



Briefs

From recent literature

No. 3 in a Series

Extreme pressure lubricants can be made substantially non-corrosive to ferrous and non-ferrous alloys by incorporating a small amount of the triethanolamine salt of the oil-soluble petroleum sulfonic acids.

2-Mercapto-oxazolines can be synthesized by reacting a 2-amino alcohol, such as monoethanolamine, with carbon disulfide at low temperature in the presence of iodine.

Sizing composition, which will neither acidify nor polymerize on aging, may be formulated using an aqueous sizing composition comprising casein, an ethanolamine, oleic acid, a defoaming agent, a preservative and water. The composition is especially useful in the processing of regenerated cellulose yarn.

Metal cleaning and rustproofing composition capable of removing oil and grease coatings, while not exposing metal surface to corrosive action or rusting, may be compounded using kerosene, triethanolamine oleate, cobalt naphthenate and water. Upon treatment with this composition, a protective film is left on the metal surface which may be flushed away with water or allowed to remain before applying paint.

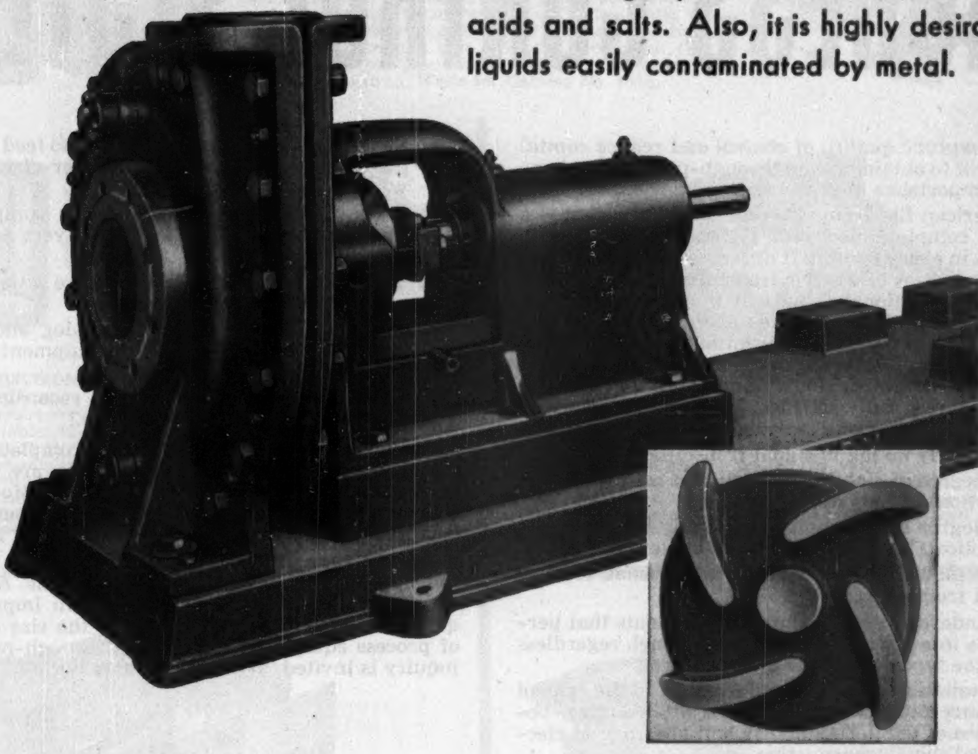
These developments are abstracted from recent publications or U. S. patents. They may suggest applications of Jefferson Ethanolamines in your products or processes.

WARREN QUIMBY PUMPS

RUBBER LINED CHEMICAL PUMPS

Warren-Quimby Type DB

For handling hydrochloric and other strong acids and salts. Also, it is highly desirable for liquids easily contaminated by metal.



Pump Casing is lined and impeller covered with Rubber

Advantages

1. Specifically built for acids and corrosive salts
2. Custom rubber lined to meet special requirements
3. Resistant to chemical corrosion
4. Resistant to physical abrasion
5. Sound rubber-to-metal bond
6. Capacities, to 2000 G.P.M., heads to 125 feet
7. Sizes, ½″ to 8″
8. Over-size bearings
9. Baseplate drip-protected

Write for Bulletin WQ-212

CQ-8

WARREN PUMPS

WARREN STEAM PUMP COMPANY, INC., WARREN, MASSACHUSETTS

NOW... A NEW, COMPLETE
ELECTRONIC
PROCESS CONTROL SYSTEM

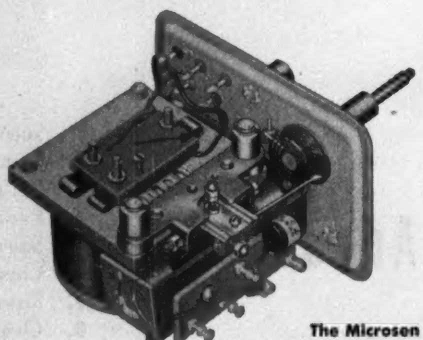
How to *improve quality of control and reduce capital investment* to obtain a given through-put are problems of vital importance in the process industries.

The American Electronic Process Control System — a new and complete electronic system — answers both problems in every respect. It utilizes all the advantages and superiorities of electric transmission of measurement and operational signals. It is the most efficient means ever developed for measuring and controlling temperature, pressure, differential pressure, liquid level and flow. Every requirement for accuracy, dependability, flexibility, low maintenance and convenient servicing is fully satisfied, because the American Electronic Process Control System provides:

1. Virtually no lag in signal transmission.
2. A degree of stability so high that narrower proportional bands can be used.
3. A degree of sensitivity practically impossible to duplicate in any other type of actuation.
4. Complete freedom from dirt, corrosion, leakage and freeze-ups.
5. Standardization of control components that permits interchange at the control panel, regardless of the type of variable under control.
6. Installation of all controllers right in the control house, any distance from the process area, because of the dependability and accuracy of electrical signal transmission.
7. Plug-in components in each instrument to simplify servicing.
8. Adaptability that permits more than one input circuit to be fed into a controller for cascading purposes, without using an additional relay.
9. Flexibility that makes it practical to feed the output signal in series to any number of receivers, without impairing accuracy.
10. Practically no investment in air compressors, filters, pressure regulators, or dryers and their maintenance.
11. Transducers for installation where a tie-in with pneumatic systems is required.
12. Suitability for service with analog and digital computational and print-out equipment for statistical and record purposes.
13. Multipoint-potentiometer type recording of all variables for permanent records.

Major instruments that make up the complete American Electronic Process Control System are pictured here. All are made by Manning, Maxwell & Moore, Inc., a company with more than a century of experience in manufacturing precision instruments for all industry.

Whatever your process control problem, we welcome the opportunity to demonstrate how the American Electronic Process Control System can improve the *quality* of your control and reduce the size and cost of process equipment for a given through-put. Your inquiry is invited. **Write for Catalog No. 164.**

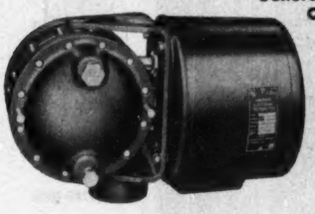


THE MICROSEN BALANCE — a compact, modified Kelvin Galvanometer structure which operates on the force balance principle — is the "nerve center" of American Electronic Instruments. It has a rectified oscillator output of .5 to 5 milliamperes which serves as the transmission signal. The transmission of pressure, differential pressure, temperature, liquid level or flow information is practically instantaneous.

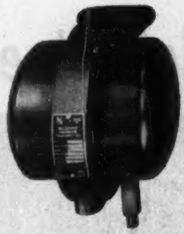
The Microsen Balance, cover removed.

AMERICAN

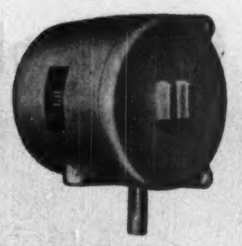
1850 U.S.A.



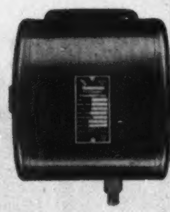
American Electronic Differential Pressure Transmitter with Barton Cell



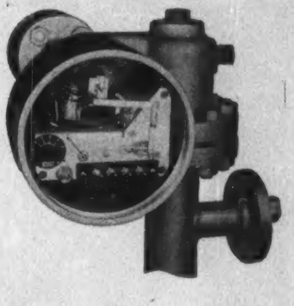
General Purpose Case



Explosion Proof Case

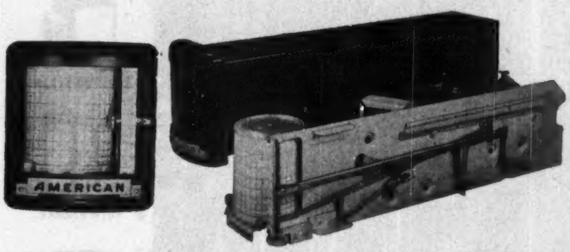


Vapor Proof Case

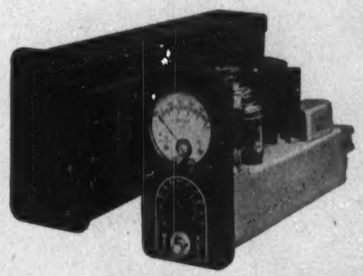


American Electronic Transmitter with Displacement Type Liquid Level Instrument

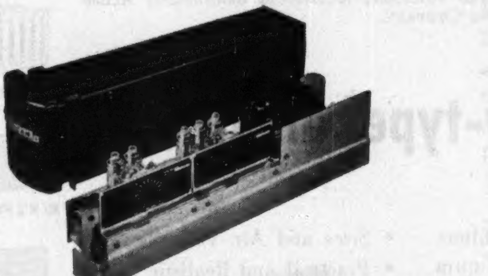
AMERICAN ELECTRONIC TRANSMITTERS are made in types to transmit temperature, pressure, differential pressure, liquid level or flow measurements. *Pressures* are measured by Bourdon tube or bellows elements; *differential pressures* by a Barton differential pressure cell; *temperatures* by standard thermocouples or thermostatic elements; *flow* by a Barton differential pressure cell; *liquid level* by a displacement type unit or a Barton cell. General purpose, vapor-proof and explosion-proof cases are available as required. **Write for Catalog No. 400A.**



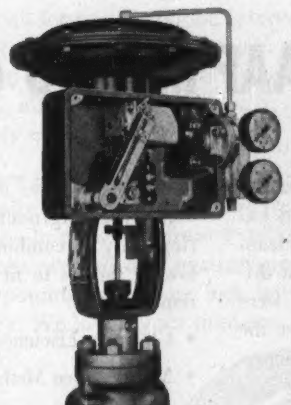
AMERICAN ELECTRONIC RECORDING CONTROL STATION, TYPE 162. A combination of two instruments: (1) a vertical scale card chart recorder which records the value of the process variable; (2) an adjustable set point which determines the control point of the Controller. Calibration of both instruments is indicated on a common scale. Motion of the recording pen is in a straight line; chart speed is ¼" per hour (one card in 24 hours). The American Electronic Indicating Control Station, Type 161, is available for applications where the recording feature is not desired.



AMERICAN ELECTRONIC MANUAL POSITIONER, TYPE 153MP. A regulated source of direct current suitable for remote loading of the electro-pneumatic valve positioner or the electro-pneumatic transducer. It is designed for use with the Type 163 Controller. Provision is made for switching between automatic and manual control without altering output current to the power device.



AMERICAN ELECTRONIC CONTROLLER, TYPE 163. Receives from the Recording or Indicating Control Station a voltage which is the output actuating signal. The output current thus automatically controls the manipulation of a process variable by means of the electro-pneumatic valve positioner or an electro-pneumatic transducer. In addition to proportional actions, *automatic reset* is provided to eliminate the effect that results from a process load change; also *rate action* to reduce the amplitude and duration of transient errors. When used with a manual positioning station, provision is made for "bumpless" transfer from automatic to manual.



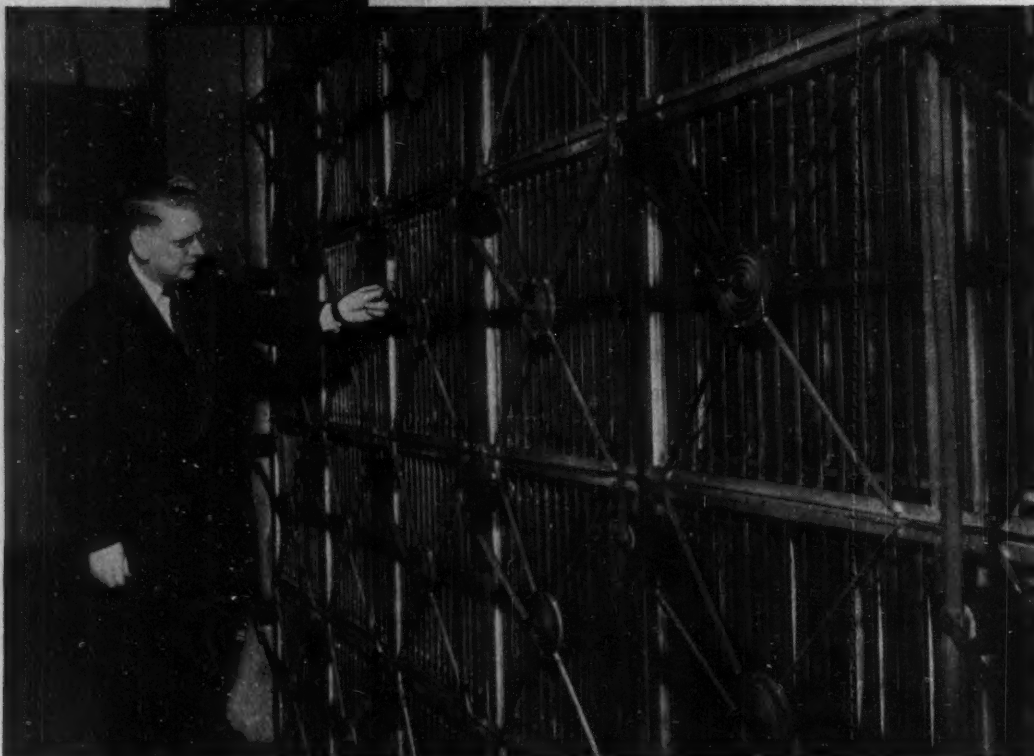
AMERICAN ELECTRO-PNEUMATIC VALVE POSITIONER, TYPE 132C. Provides precision positioning of all standard pneumatically powered valves by an electric signal. May be used with either air-to-open or air-to-close valves. A split range model is available for sequential operation of 2 or 3 valves from a single transmission circuit. As an example of speed of response, in a valve having a final volume of 65 cubic inches, the time required to reach full stroke position is less than 3 seconds.

INDUSTRIAL INSTRUMENTS

A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONNECTICUT

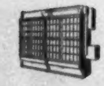
MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'HANCOCK' VALVES, 'ASHCROFT' GAUGES, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, AIRCRAFT PRODUCTS. BUILDERS OF "SHAW-BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES.

only AAF makes the complete line

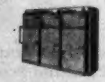


AAF's ELECTRO-PL—an exclusive development of AAF engineering research, and the world's only dry-type electronic air filter! It offers these important advantages • Low initial cost • Easy installation • Simple economical maintenance • Safety in operation • Efficient air filtration even when there are power failures.

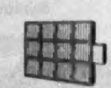
In the above photograph we show part of the ELECTRO-PL installation which provides a constant clean air volume of 95,000 cfm for the Bell Savings and Loan Association Building in Chicago, Illinois. Architects and Engineers: JOHNSON AND JOHNSON; *Mechanical Contractors:* ACORD VENTILATING COMPANY.



ELECTRO-MATIC

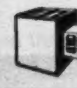


* ELECTRO-CELL

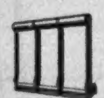


* ELECTRO-PL

ELECTRO-MIST



* ELECTRO-KLEAN

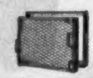


* AUTO-AIRMAT

* AIRMAT PL-24

DEEP-PAK *

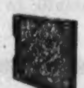
* DEEP BED



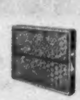
M/W & HV UNITS

* DRIFILTER

MULTI-DUTY



RENU-GLAS



AMER-GLAS

Why does AAF make 8 dry-type* air filters?

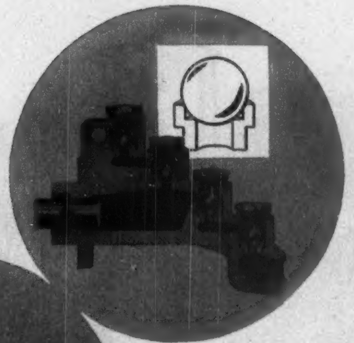
The answer is simple, but *important* to all Engineers and Executives responsible for air cleaning applications. These eight different dry-type air filters were specially designed to meet the complex combination of factors facing the engineer in solving dust and air contamination problems.

AAF's eight types of dry filters offer the engineer maximum flexibility in combining the following factors to fit specific job requirements:

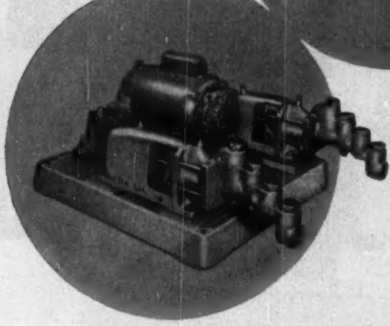
- Cleaning Efficiency
- Maintenance Methods
- Space Requirements
- Sizes and Air Volumes
- Practical and Realistic Range of Costs

Our nation-wide Sales and Engineering staff is at your disposal. Please write or wire .... no obligation of course. Fully descriptive literature on all of these AAF filters is available on request.

American Air Filter
COMPANY, INC.
326 Central Avenue, Louisville 8, Ky.
American Air Filter of Canada, Ltd., Montreal, P. Q.



Basic design simplicity of the exclusive Milton Roy liquid end step-valve assures high and reproducible volumetric efficiency. The self-cleaning *double* ball-checks seat positively, dislodge any trapped particles by spinning action, are snap-acting.



Chemical Treatment Costs Drop with this Milton Roy Pump

CONTROLLED VOLUME PUMPING

INSTRUMENTATION

PROCESS CONTROL SYSTEMS

BLENDING AND FORMULATING

On The Job in a well-known chemical processing plant, this Milton Roy Motor-Driven Controlled Volume Pump meters the flow of concentrated sulphuric acid to the deoiling step in an ore flotation process. The accurate control of acid addition results in minimum usage of concentrated sulphuric acid and subsequent caustic, thereby lowering treatment costs.

This is a typical example of how Milton Roy Pumps effect dollar savings in hundreds of applications throughout industry. As motor-driven or air-powered units, or as components of automatic systems, their accuracy and long service life bring measurable returns to users. In *boiler feed water treatment,* for example, they are used in all forms of handling internal or external treating chemicals; in *petroleum processing,* for crude desalting and gasoline treating; in *textile manufacturing,* for acid, alkali or bleach baths; in *instrumentation,* to satisfy control requirements.

These are rugged, dependable pumps. They meter practically any liquid—abrasive slurries, solids in suspension, solvents—in capacities from 3 milliliters per *hour* to 45 gallons per *minute,* against pressures up to 25,000 pounds per square inch with instrument accuracy. We invite your inquiries.

Bulletin No. 553 tells you how you can profitably use Milton Roy Motor-Driven Controlled Volume Pumps in your business. Write for your **free** *copy.*

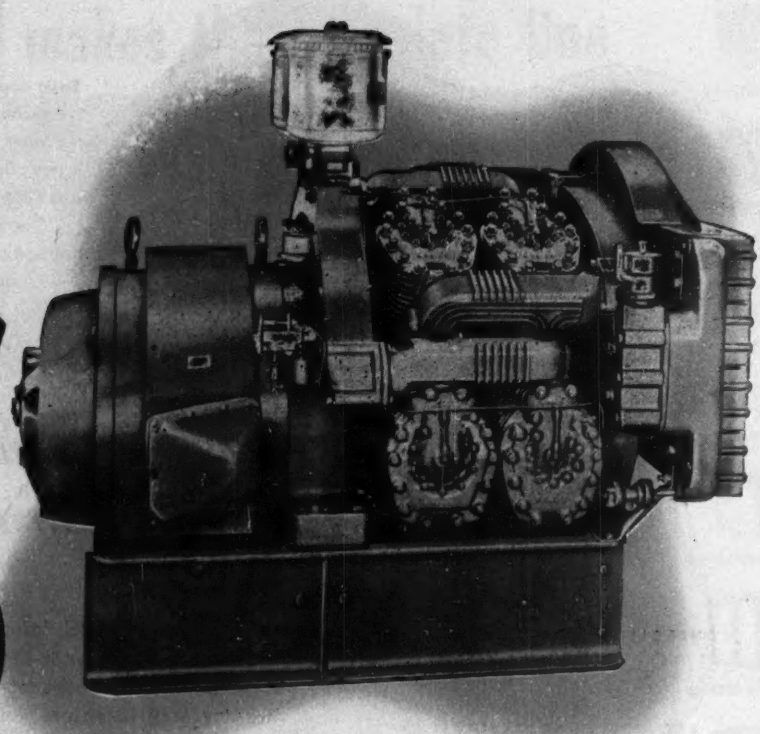
Engineering Representatives in the United States, Canada, Mexico, Europe, Asia, South America and Africa.

Milton Roy Company

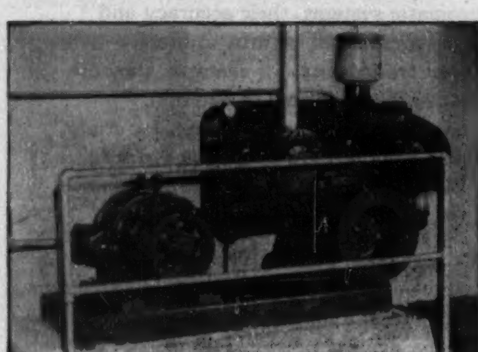
Manufacturing Engineers • [illegible] E. MERMAID LANE • PHILA. 18, PA.

CONTROLLED VOLUME PUMPS AND AUTOMATIC CHEMICAL FEED SYSTEMS

JOY WL-80 COMPRESSOR with automatic start and stop control



A Real "Package-Unit"



JOY COMPRESSORS meet any need!
Air-cooled or heavy duty water-cooled; complete range from 1.4 to 8800 CFM, ¼ to 600 HP.

Joy WL-80's are ideal for the smaller air-requirement jobs, or for de-centralized air supply, etc. These two-stage, air-cooled units are delivered ready-to-go, complete with air receivers, piping and wiring if you wish—just hook them up to power and air lines. Extremely compact and efficient, a WL-80 will fit into any small corner of your plant. You can eliminate long runs of piping; compress the air right where you use it. Available in eleven sizes from 15 to 125 HP, 81 to 641 CFM, with pressures to 125 PSI, for service indoors or out. ● *Write for Bulletin A-56.*

Joy also makes a complete line of Oil-Free Compressors for applications where air must be free of any lubricant. *Write for details.*

Consult a Joy Engineer

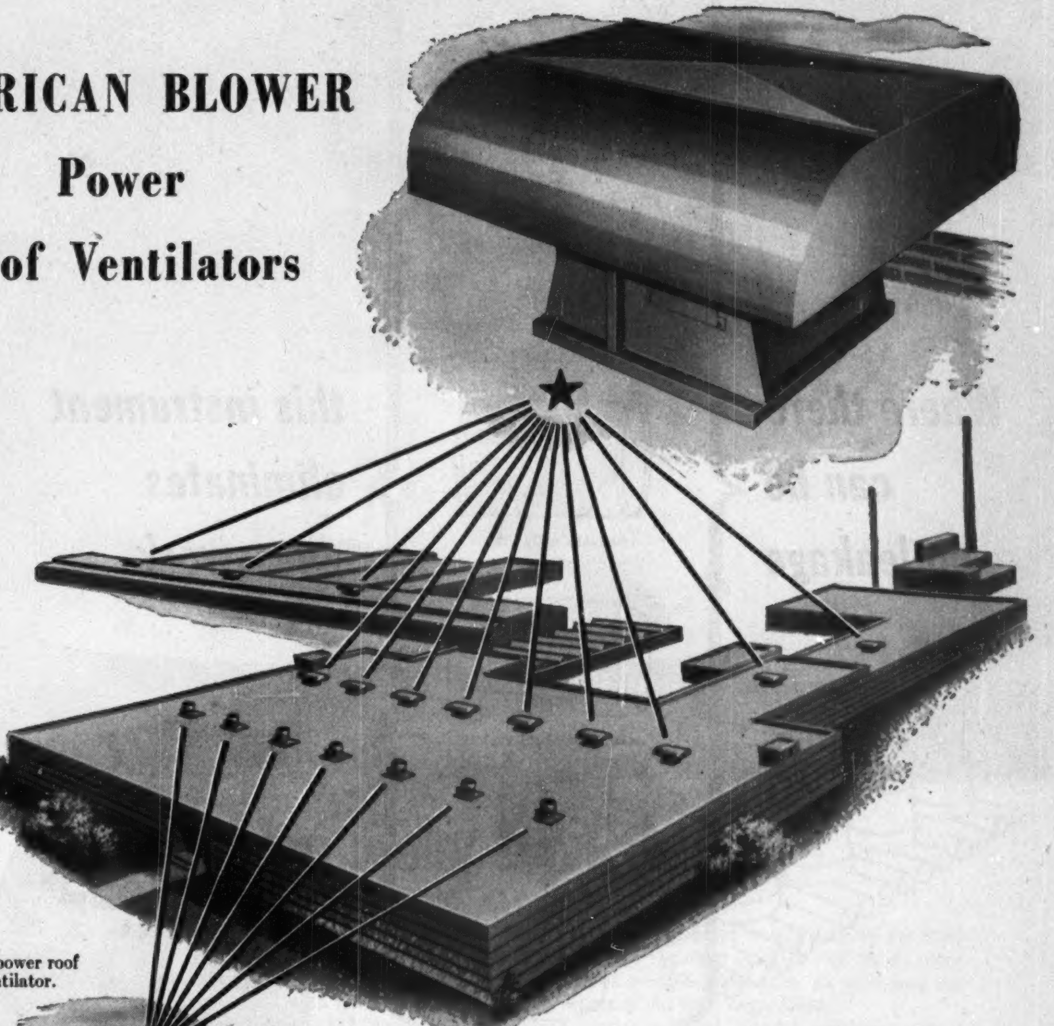
Over 100 Years
of Engineering Leadership

W&D I 4060

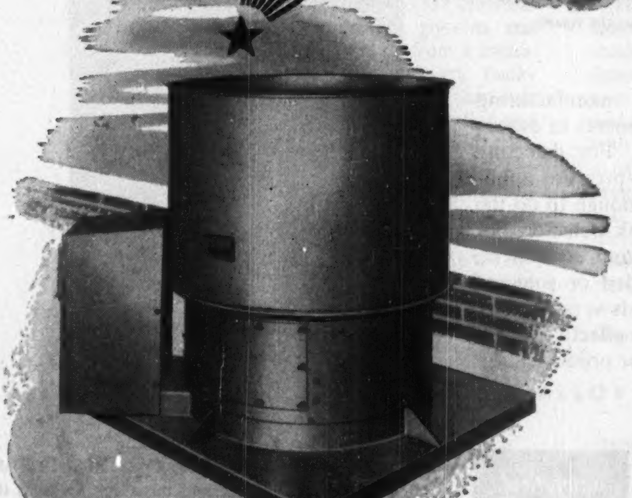
JOY MANUFACTURING COMPANY
GENERAL OFFICES: HENRY W. OLIVER BUILDING · PITTSBURGH 22, PA.
IN CANADA: JOY MANUFACTURING COMPANY (CANADA) LIMITED, GALT, ONTARIO

AMERICAN BLOWER
Power
Roof Ventilators

Hood type power roof exhaust or supply ventilator.



Upblast type power roof exhaust ventilator.



American Blower *power* roof ventilators give you the advantages of balanced ventilation, without the uncertainties of gravity units or the expense of a central system.

They're quickly and easily installed on all types of roofs. No extensive duct work is required; no valuable floor space is wasted. Use single units for spot ventilation; several units for large area coverage. American Blower power roof ventilators, supply or exhaust, are available in a wide range of capacities. They are designed to furnish balanced ventilation to industrial plants and commercial buildings.

Ask our nearest branch office for data.

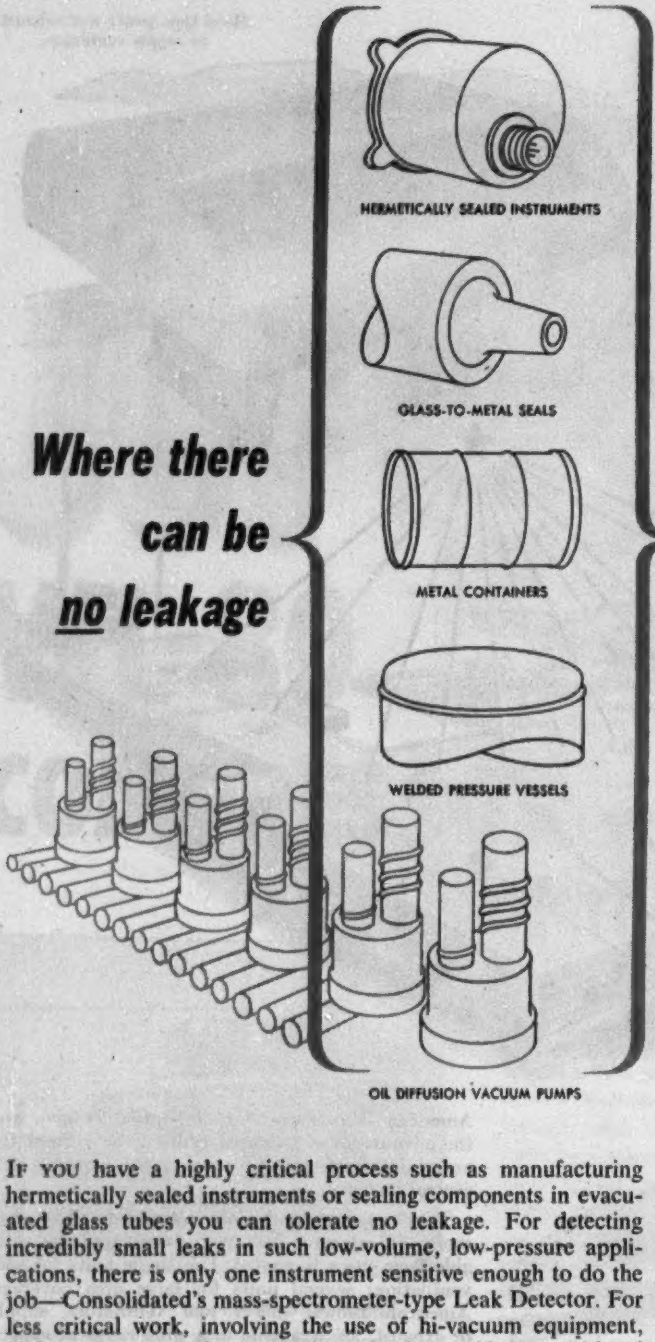
AMERICAN BLOWER CORPORATION, DETROIT 32, MICHIGAN
CANADIAN SIROCCO COMPANY, LTD., WINDSOR, ONTARIO

Division of American Radiator & Standard Sanitary corporation

AMERICAN BLOWER

YOUR BEST BUY IN AIR HANDLING EQUIPMENT

Serving home and industry: AMERICAN-STANDARD • AMERICAN BLOWER • CHURCH SEATS & WALL TILE • DETROIT CONTROLS • KEWANEE BOILERS • ROSS EXCHANGERS

Where there can be <u>no</u> leakage {  } **this instrument eliminates guesswork**

IF YOU have a highly critical process such as manufacturing hermetically sealed instruments or sealing components in evacuated glass tubes you can tolerate no leakage. For detecting incredibly small leaks in such low-volume, low-pressure applications, there is only one instrument sensitive enough to do the job—Consolidated's mass-spectrometer-type Leak Detector. For less critical work, involving the use of hi-vacuum equipment, high-pressure cylinders, containers having welded or soldered joints, or valves moving on an assembly line, this versatile leak detector is the perfect instrument, guarding the effectiveness of your process and guaranteeing the quality of your product.

Consolidated Engineering
CORPORATION
300 North Sierra Madre Villa, Pasadena 15, California

Sales and Service through **CEC INSTRUMENTS, INC.,** *a subsidiary with offices in: Pasadena, Philadelphia, New York, Chicago, Dallas*

analytical instruments for science and industry

Leak Detector *Consolidated's Model 24-101A* detects, locates, and measures leaks in the micron range where it would take 31 years for one cubic centimeter of gas to escape. Request CEC Bulletin 1801-X3.

24 ACRES *Cover the World*

. . . with TOP QUALITY

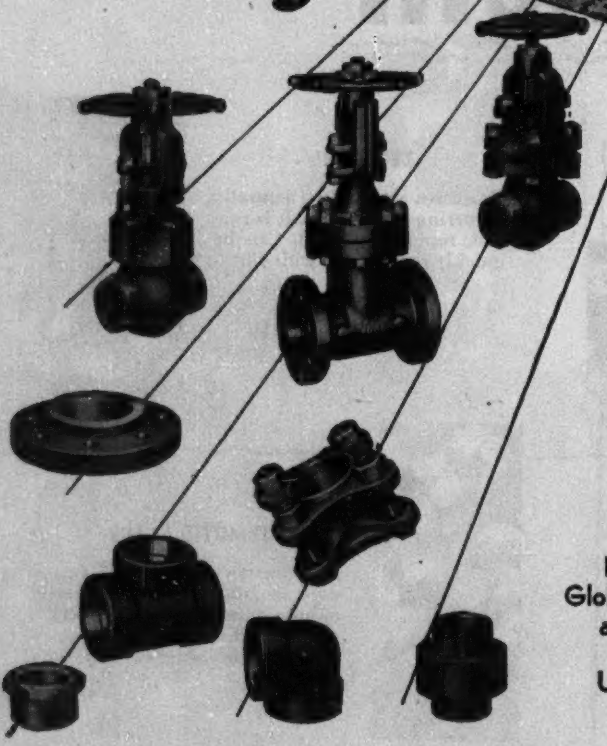
DROP FORGED STEEL

VALVES, FITTINGS and FLANGES

by

Vogt

Air View of
Henry Vogt Machine Co.



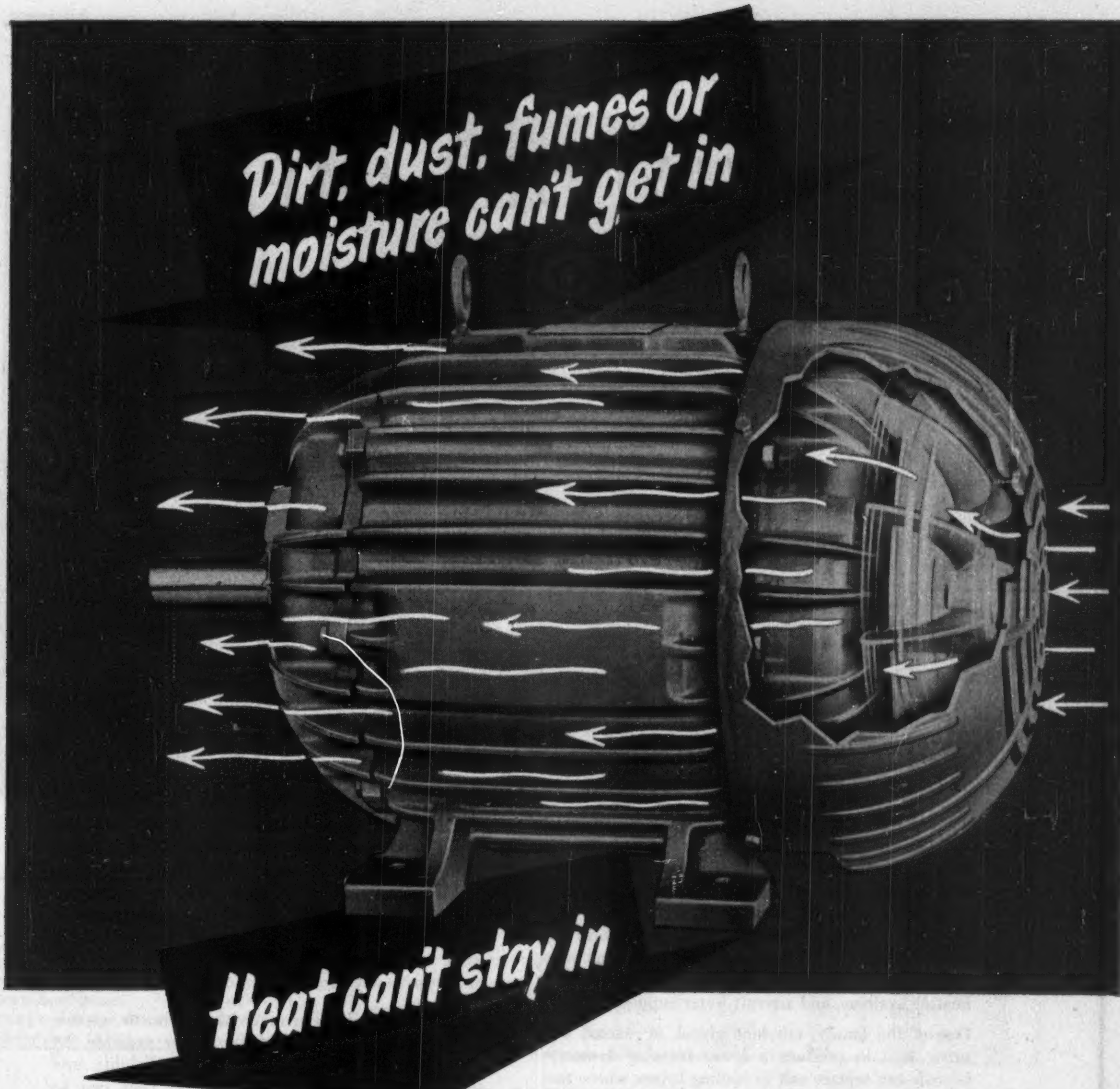
This 24 acre Vogt plant supplies the most comprehensive line of top quality *drop forged* steel piping materials anywhere available to industry. That's why they're the choice of leading refineries, power plants, chemical plants, etc., the world around!

OUR COMPLETE LINE INCLUDES

Flanged, Screwed and Socket Weld End Globe, Gate and Check Valves • Ells, Tees and Crosses • Couplings • Bushings • Plugs • Unions • Flanges and Flange Unions • Welding Heads

HENRY VOGT MACHINE CO. LOUISVILLE 10, KY.

Branch Offices: New York, Philadelphia, Chicago, Cleveland, St. Louis, Dallas, Charleston, W. Va.



ELLIOTT CROCKER-WHEELER
Sealedpower MOTOR

■ Here's a motor that doesn't care how tough the conditions are. Blizzards of dust or grit can't affect it—not only can't get *in,* but can't even stay *on* the outer case. The powerful fan-driven, cowl-directed air blast sweeps it off, and also drives off the heat radiated from the many fins.

Easy to see why this Sealedpower motor has for **eleven years** been the ace-in-the-hole among engineers who are confronted with drive conditions that would defeat ordinary motors.

Thousands now in service, and going strong in oil refineries, lumber mills, chemical and textile plants, outdoor and indoor installations everywhere. 3 to 125 hp. Also as explosion-proof underwriters approved in most ratings. Get the facts. Address Elliott Company, Jeannette, Pa., or your nearest Elliott district office.

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For large motors: RIDGWAY DIV., RIDGWAY, PA.
Plants at: JEANNETTE, PA. • RIDGWAY, PA.
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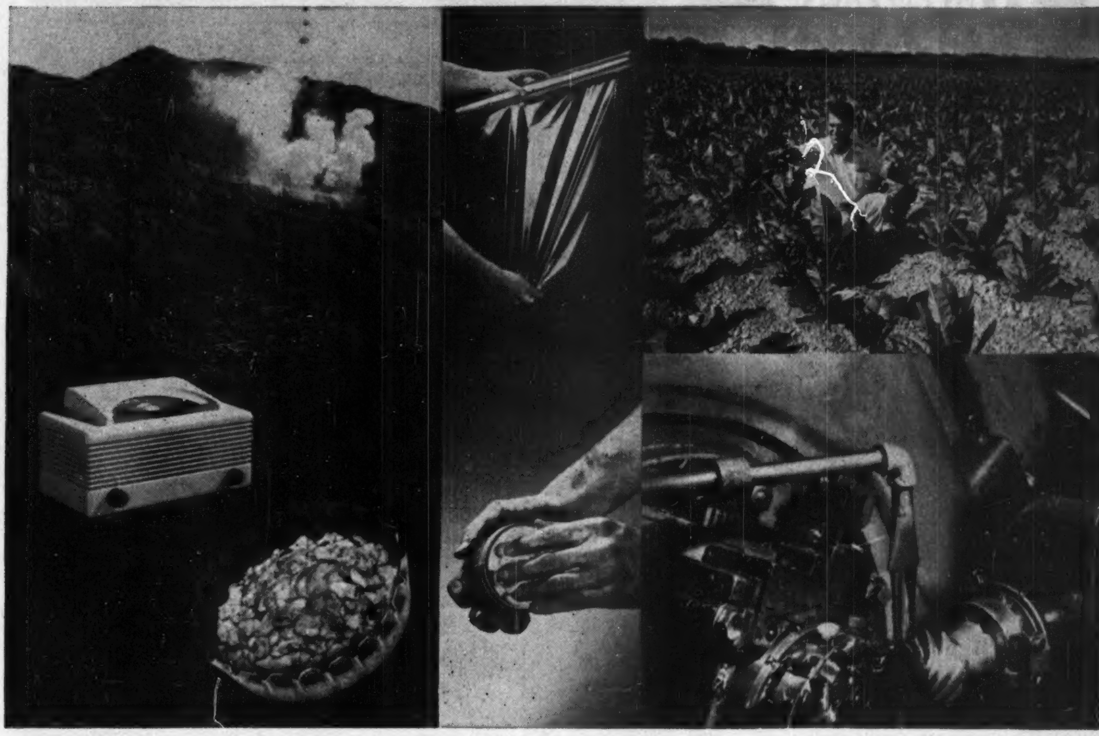
ELLIOTT APPROVED SERVICE SHOPS COVER THE COUNTRY

W2-8



PROPERTIES OF THE GLYCOLS

	Chemical Formula	Molecular Weight	Specific Gravity 25/25°C.	Freezing Point °F.	Boiling Point °F.	Flash Point °F.	Fire Point °F.
Ethylene Glycol	$HOCH_2CH_2OH$	62.1	1.113	7	390	240	245
Diethylene Glycol	$HOCH_2CH_2OCH_2CH_2OH$	106.1	1.116	16	475	275	290
Triethylene Glycol	$HOCH_2CH_2OCH_2CH_2OCH_2CH_2OH$	150.2	1.122	22	545	310	345
Propylene Glycol, Industrial	$CH_3CHOHCH_2OH$	76.1	1.036	(−80)*	369	215	215
Dipropylene Glycol	$CH_3CHOHCH_2OCH_2CHOHCH_3$	134.2	1.026	(−54)*	446	250	255

*Pour Point

SPECIFICATIONS OF THE GLYCOLS

	Specific Gravity at 25/25°C.	Boiling Range 760 mm. Hg 5 to 95%	Acidity, Max. (As Acetic Acid)	Water Max.	Color Apha Max.
Ethylene Glycol	1.112-1.115	194-200°C.	0.01%	0.5%	15
Diethylene Glycol	1.115-1.118	240-251°C.	0.01%	0.2%	—
Triethylene Glycol	1.121-1.125	275-295°C.	0.01%	0.1%	60
Propylene Glycol, Industrial	1.035-1.037	185-190°C.	0.005%	0.5%	10
Dipropylene Glycol	1.018-1.028	220-240°C.	0.01%	0.1%	20

The Dow Chemical Company, Dept. OC 3-21
Midland, Michigan

☐ Please send me additional literature about the glycols.

☐ Please send ________ reprints of this advertisement.

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Title________________________

Company________________________

Address________________________

City________________ State________

This is one of a series of Dow advertisements you may wish to keep on file for reference and information. Write Dow for reprints.

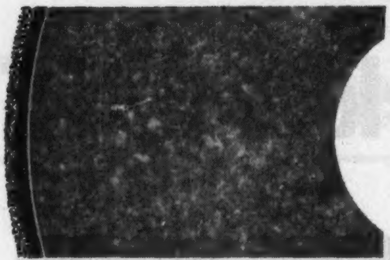
you can depend on

DOW CHEMICALS

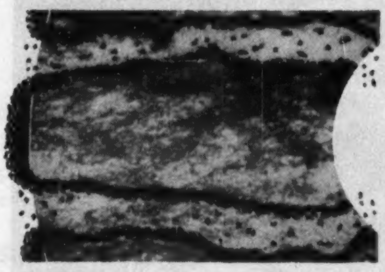
GRADUATED DENSITY

makes MICRO-KLEAN the most effective filter on the market!

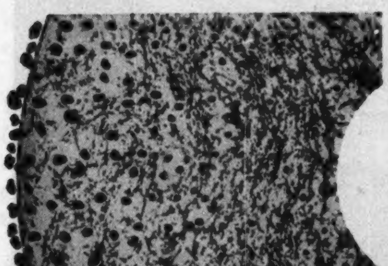
How MICRO-KLEAN compares with other cartridge filters



Compare MICRO-KLEAN with FILTERS WITH THE SAME DENSITY THROUGHOUT. The filter media density is the same on the pressure and discharge surfaces of the element; therefore, dirt accumulation is largely on the outside surface, choking the cartridge ("plastering") and reducing the effective filter life.



Compare MICRO-KLEAN with FILTERS WITH HAPHAZARD DISTRIBUTION OF FILTER MEDIA. Uneven haphazard media density permits fluid to find channels through the filter, and pass solids larger than the minimum filter spacing.



Now Look at the advantages offered by MICRO-KLEAN. See how the fibre density increases toward the discharge side of the MICRO-KLEAN filter cartridge? In effect, every Cuno MICRO-KLEAN cartridge is an infinite multiplicity of screens, ranging from relatively coarse on the outside down to 10 microns in the center. Because of MICRO-KLEAN's graduated density in depth, particles are entrapped within the entire depth of the filter element, giving the cartridge a much longer effective life. Standard cartridge size is 9¾" long by 2¾" O. D., in densities of 10, 25 and 50 microns.

MICRO-KLEAN gives you

- greater dirt holding capacity
- absolute protection against rupturing or channeling of the cartridge
- longer effective cartridge life

REMEMBER ... IF YOU CAN PUMP IT, CUNO CAN FILTER IT

M.3.C

CUNO

ENGINEERED FILTRATION

Removes More Sizes of Solids From More Kinds of Fluids

AUTO-KLEAN (disc-type) • MICRO-KLEAN (fibre cartridge) • FLO-KLEAN (wire-wound)

MICRO-KLEAN FILTER HALVES CARTRIDGE REPLACEMENT COSTS

Resin Impregnated Fibre Cartridge Lasts Twice as Long

MICRO-KLEAN's graduated density-in-depth allows greater capacity for dirt accumulation within the micronic cartridge, giving twice the effective life of an ordinary filter cartridge. Thus, cartridge replacement costs are cut in half. And the high porosity of MICRO-KLEAN permits higher flow rates, enabling you to speed up fluid processing.

Each fibre of the MICRO-KLEAN filter is positively bonded in position by resin impregnation and polymerization. This provides great structural strength and complete protection against channeling, rupturing, shrinking or distortion.

Cuno's exclusive method of felting fibres permits precision control of the cartridge structure, assuring MICRO-KLEAN users of consistent, uniform filtration.

MICRO-KLEAN's low pressure drop operation permits full-flow service on gravity, low pressure, or suction lines—with no loss in operating efficiency.

Try a MICRO-KLEAN cartridge in your replaceable-element type filter. Standard sizes fit many types of industrial filters now in use. Special lengths of MICRO-KLEAN cartridges can be supplied for built-in installations. MICRO-KLEAN cartridges also come in a wide range of Cuno housings.

Take advantage of Cuno's unique "money-back" offer: if MICRO-KLEAN doesn't outperform any filter cartridge you have previously used, we'll send you *double* your money back. Send coupon today for MICRO-KLEAN bulletin.

M.3.1

Cuno Engineering Corporation
Dept. 101C South Vine Street, Meriden, Conn.

I'm interested in your "money-back" offer. Please send me bulletin on Cuno MICRO-KLEAN.

Name..............................

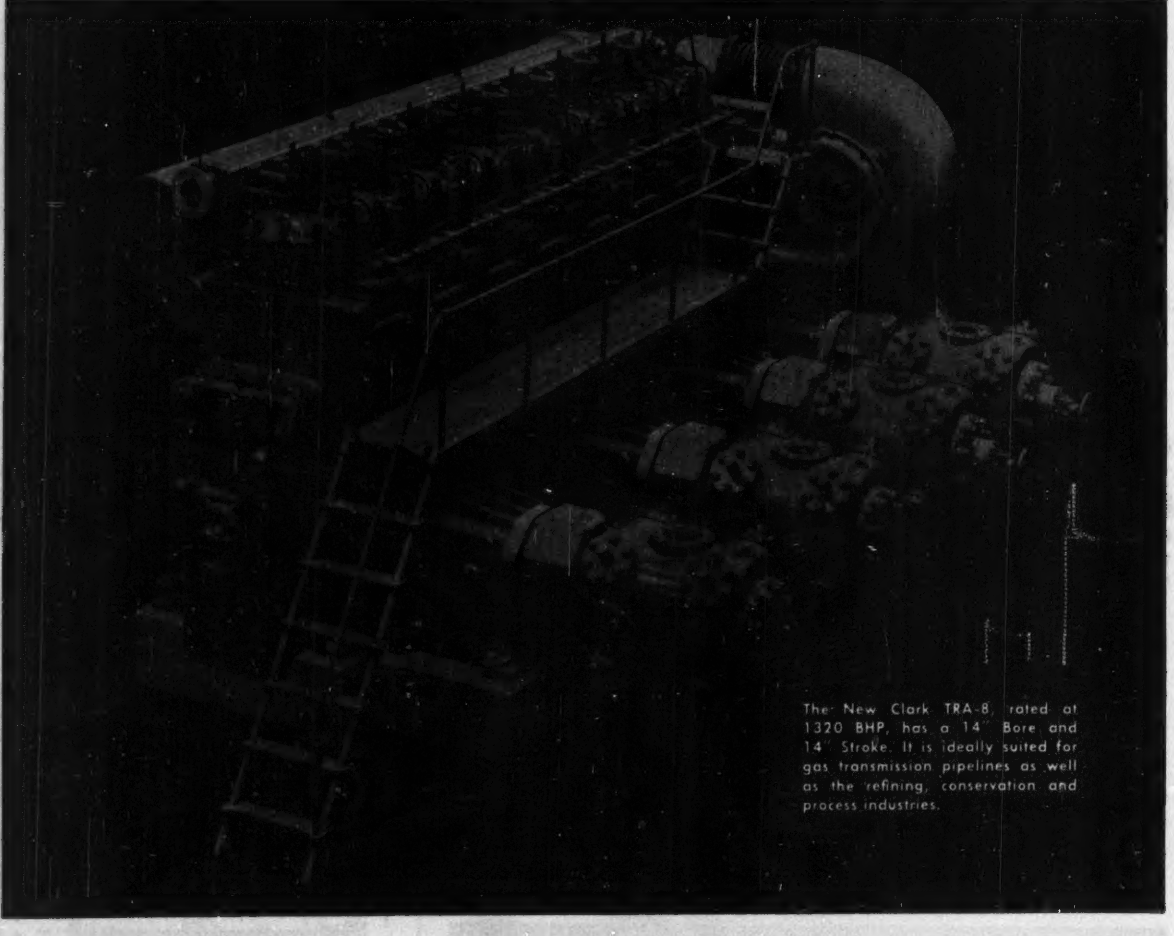
Company..............................

Address..............................

City................Zone....State......

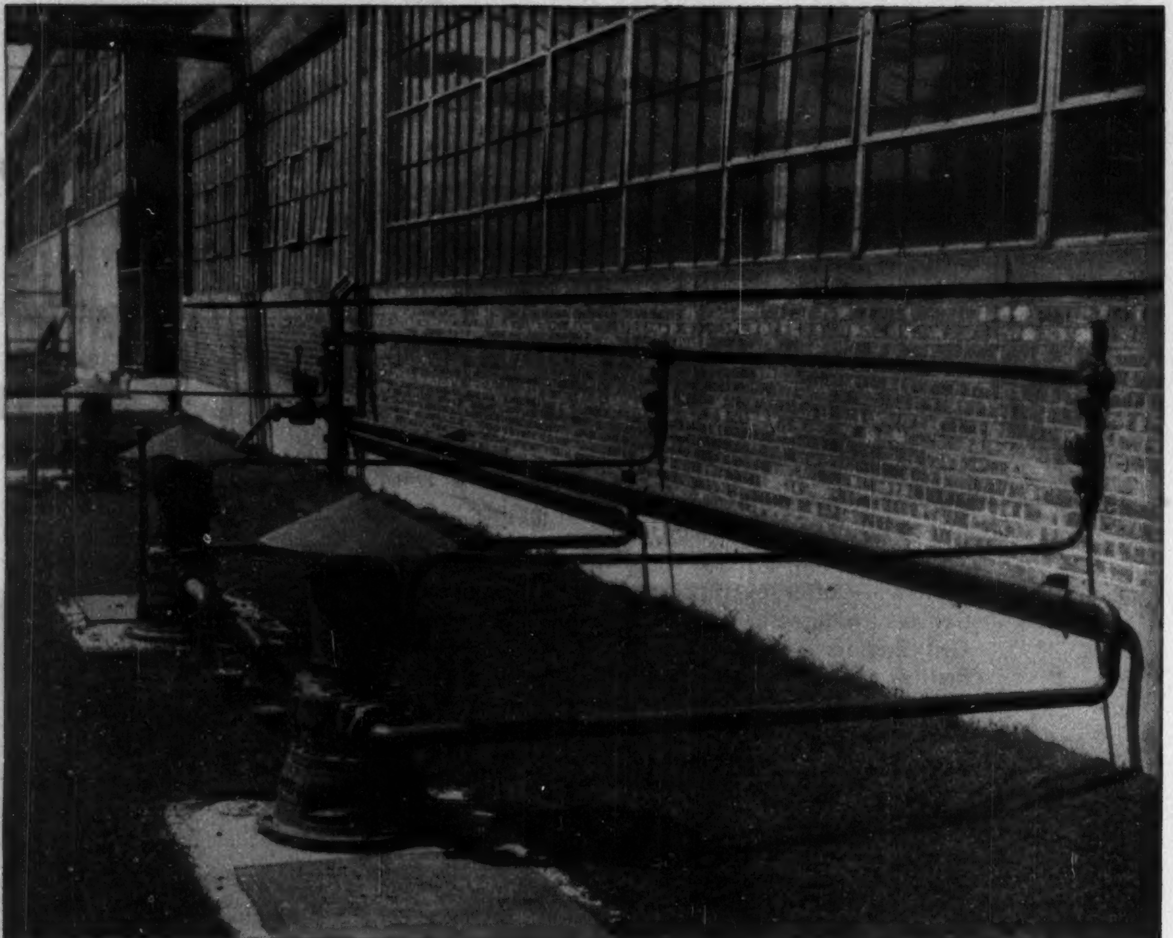
IT'S HERE! a

The NEW Clark 2-Cycle

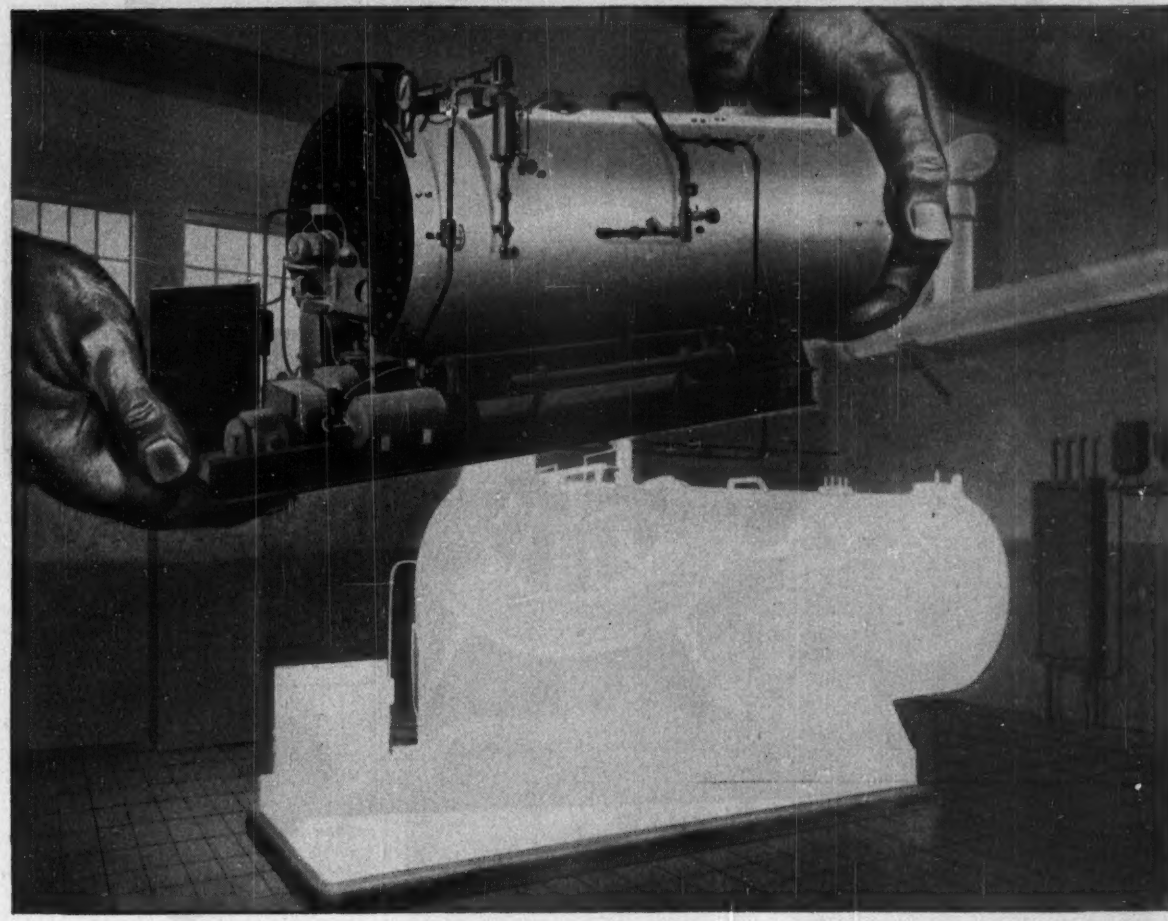


The New Clark TRA-8, rated at 1320 BHP, has a 14" Bore and 14" Stroke. It is ideally suited for gas transmission pipelines as well as the refining, conservation and process industries.

Clark Continues to Set the Pace in Compressor Progress



Here's why you get more...when you buy a Cleaver-Brooks Self-Contained Boiler



...only Cleaver-Brooks can offer you the experience gained from more than 20 years of pioneering . . . and more than 12,000 individual "packaged" boiler installations

Cleaver-Brooks pioneering has been largely responsible for simplifying boiler buying . . . lowering costs of installation . . . delivering 80% guaranteed steam efficiency from every fuel dollar.

Boilers can be shipped as completely assembled and tested self-contained units, with auxiliaries as required. Installation involves minimum of time, construction and space. Usually connections only to steam, fuel, water lines and electrical service are needed. No special foundations are required. A short vent takes care of exhaust gases. Frequently, boilers are ready for use in a matter of *hours*, depending on availability of service lines.

Cleaver-Brooks, originators of the self-contained boiler, offers wider experience that counts in another important way. Qualified engineers help you plan steam plants tailored *exactly* for your needs. Carefully analyzed are loads, space and equipment arrangement. This not only helps you solve present steam needs, but adds flexibility for future expansion as well.

This application engineering, plus basically sound design and construction is your assurance of a full return from your boiler investment. When you specify a self-contained boiler — make sure it's a Cleaver-Brooks.

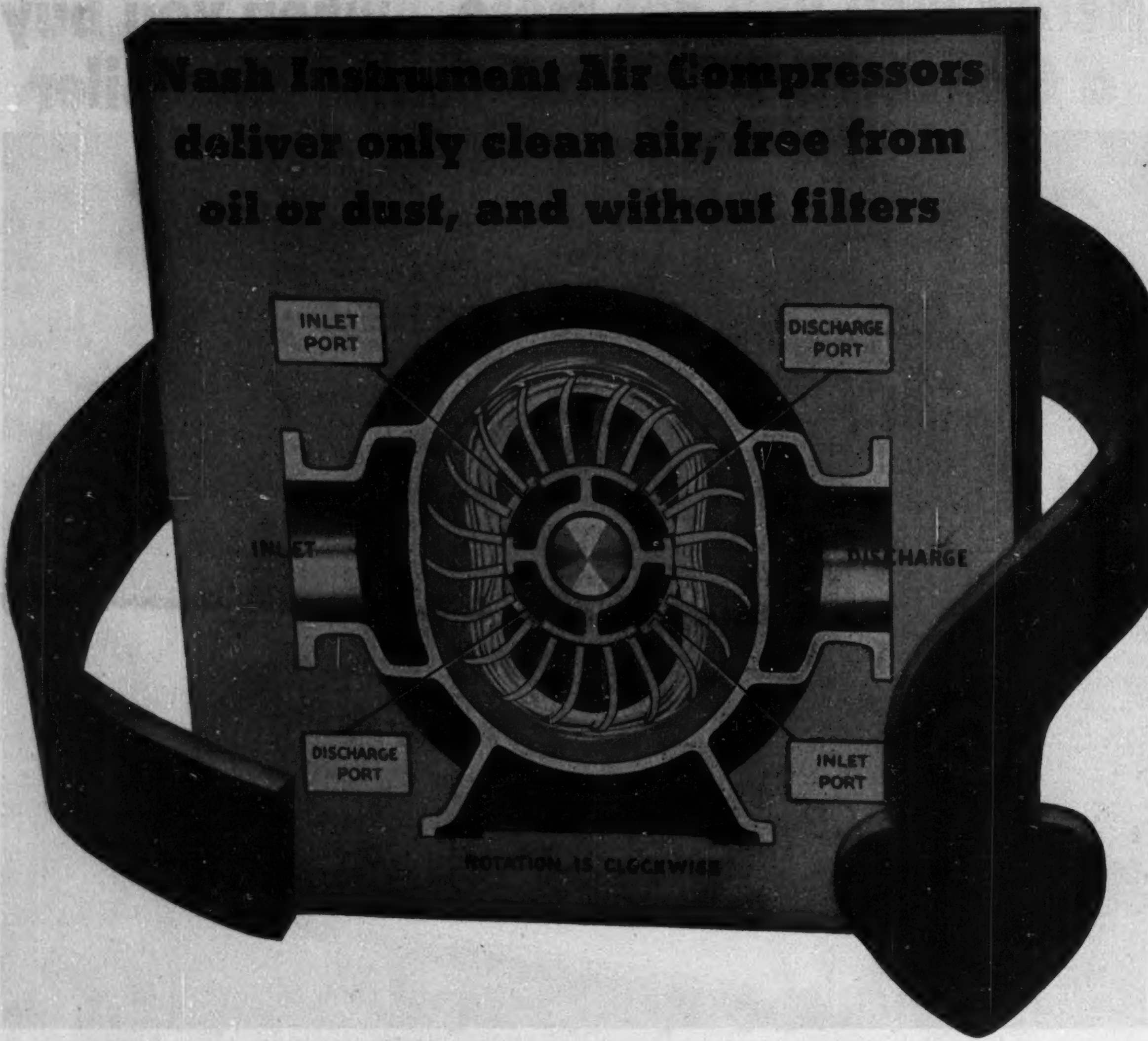
Send for Catalog AD-100 for full details on Cleaver-Brooks boilers. Available for oil, gas and combination oil/gas firing. Sizes 15 to 500 hp, 15 to 250 psi — for heating and processing.

CLEAVER-BROOKS COMPANY
Dept. G, 345 E. Keefe Ave.
Milwaukee 12, Wisconsin, U.S.A.

Cleaver-Brooks

ORIGINATORS OF THE SELF-CONTAINED BOILER

Steam Boilers • Oil and Bitumin Tank Car Heaters • Distillation Equipment
Oil and Gas Fired Conversion Burners


Nash Instrument Air Compressors
deliver only clean air, free from
oil or dust, and without filters
INLET PORT
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ROTATION IS CLOCKWISE

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U.S.I. CHEMICAL NEWS

★ A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries ★

To Use Sodium Reduction in First Fatty Alcohol Plant

Metallic sodium will soon be instrumental in making an important new series of products available to the detergent field, according to a recent announcement. The products are long-chain fatty alcohols, which are obtained from tallow through a reduction reaction with sodium. Production of these materials, the first in this country, is scheduled to begin shortly in a new plant with a capacity of 1.5 million pounds per year.

The present process is scaled to batches requiring one drum of sodium at a time. The sodium is melted, dispersed in toluene, and added to a mixture of tallow, methyl isobutylcarbinol, and toluene in a reactor. Reduction is carried out at 110-115° C. under a blanket of nitrogen. The reaction splits the tallow glycerides, yielding a mixture of caustic, glycerine, fatty alcohols, and solvent. Components of the mixture are separated in a settling tank, after which the fatty alcohols are purified by vacuum distillation.

Detergents, including new bar detergents, are expected to be the chief outlets for the alcohols. Other markets are seen in water repellents, plastics, oil additives, and cosmetics.

Find Rare Earth Metals Make Good Paint Driers

The rare earth metals have entered the paint drier field with good results, it was revealed at a recent technical meeting. According to the report, investigators obtained what was termed startling results in white refrigerator enamel with a solution of rare earth naphthenate consisting of 50 per cent cerium and 50 per cent lathanum. Field tests on epon resins, styrenated alkyds, silicones, and oleoresinous baking alkyds are said to have confirmed laboratory results of cleaner, tougher, better adhering films. Improved soap and water resistance is also claimed.

U.S.I.'s Newest Chemical To Save Scarce Hand Labor In Nation's Cotton Fields

CIPC Now Available to Herbicide Formulators; Applied to Soil During Planting, Chemical Controls Crab Grass, Other Weeds, in Cotton

U.S.I.'s most recent addition to its chemical line, CIPC, is expected to play an increasingly important part in reducing the cost of controlling weeds in the nation's future cotton crops. According to the National Cotton Council, a substantial part of the cost of producing cotton is made up of expenditures for weed control — which must be done largely by hand hoeing operations. Increased labor requirements as well as growing shortages of labor have sharply increased these costs in recent years. Competition for the steadily decreasing labor force in the South is expected to drive them still higher in the future. CIPC is seen by many as a solution to the problem.

Left: Weed control results after application of CIPC at the rate of two pounds per acre. No manual weeding has been required. Right: Untreated check plot in the same field. Plants in both pictures are, bottom to top, green beans, corn, peanuts, soybeans, and cotton.

CIPC "Weeds As You Seed"

CIPC, designated chemically as isopropyl N-(3-chlorophenyl) carbamate, is a close relative of IPC, another useful herbicide which U.S.I. began producing commercially last year. Like IPC, it is primarily a pre-emergence herbicide, i.e., it works best when applied to the soil before the weed seeds germinate, or shortly thereafter. In certain

MORE

Return of Wastes to Soil Termed Essential

Inorganics, Conditioners Not Complete Replacements for Soil Losses; Relationship Seen Between Organics and Antibiotic Formation in Soil

In a recent paper on the general subject of returning wastes to the soil, it was pointed out that there are indications of a direct relationship between the return of organic matter to the soil and the formation of antibiotics in the ground. This was declared to be an entirely new concept in the control of plant diseases. One example cited was recent work which showed soil-borne parasites to have been suppressed by heavy manuring of infected soils with organic matter.

Farm Wastes A Rich Source of Organics

With continued vigorous cultivation of the land, organic matter has been vanishing from our soils in spite of great mechanical and technological achievements in agriculture. Half the tonnage of our food production above the ground is inedible to man and is usually wasted, it was said. It has been estimated that several hundred million tons of crop residues and agricultural wastes, which are not used for chemurgic or feeding purposes, remain on farms each year.

Listeners were reminded that organic matter exerts beneficial effects on the physical, chemical, and biological properties of soil, and that inorganics alone are not enough to keep the soil at peak productivity. It was recommended that under practical conditions

MORE

U.S.I. CHEMICAL NEWS

CONTINUED Weed Control

cases, however, CIPC can also be used to advantage in post-emergent applications. Once in the soil, CIPC appears to disrupt cell division within susceptible plants, after which the plant stops growing and dies. CIPC is most effective when it is applied at the same time the seed is sown.

CIPC, like IPC, is manufactured by U.S.I. for use by herbicide formulators. The company does not supply finished farm herbicides.

Provides Effective Control of Crab Grass

Tests by the U.S. Department of Agriculture and others have shown CIPC to be an effective herbicide against many annual weedy grasses and broad-leaved plants, and at the same time to have little or no effect on certain valuable plants. For example, it is particularly effective against the weed enemies of cotton, including crab grass, which is perhaps the worst and most difficult to kill, but it does not harm the cotton itself. In some cases, one application of CIPC makes further weed eradication unnecessary.

If applied to the soil when the cotton is sown, CIPC provides efficient, dependable control of weeds and reduces or entirely eliminates hoeing operations. Thus, it is expected to greatly reduce hand labor requirements and to cut weed control costs for the cotton planter.

Curtails Dangers of Over-Cultivation

Another advantage seen for the new "weed as you seed" herbicides, such as IPC and CIPC, is that they reduce the danger of adversely affecting crop yields through over-cultivation. For example, too deep and too frequent cultivations of cotton have definitely been shown to reduce cotton yields. Chemical weed control eliminates this possibility as well as the mechanical injuries which often accompany the most careful cultivations.

CIPC Effective for Other Crops

In addition to cotton, tests have shown soybeans, peanuts, lima beans and snap beans to have considerable tolerance to pre-emergence applications of CIPC. Post-emergence applications have given good results in the control of chickweed and annual weedy grasses in stands of pure alfalfa.

CONTINUED Organic Wastes

there should be a regular cycle whereby some of the nutriment taken from the soil by plants is later reverted to the soil.

Role of Composts Emphasized

Composting was emphasized as an age-old but still highly effective method for treating wastes before returning them to the soil. Composting, it was stated, results in biological stabilization of organic matter so that it has greater utility in improving the physical nature of soil particles. It has been found that preliminary decomposition of organic matter can be hastened in the composting process by addition of distillery molasses residues or fertilizers. Finished composts are applied at the rate of three to four tons of dry matter per acre and can be used in farm practice as a substitute for manures.

A need was expressed for much more basic knowledge concerning microbially derived fractions of soil organic matter before various theories can be clarified. The author predicted, however, that additional research will show that the return of organic matter to the soil is economically sound as well as most necessary for conservation and maintenance of soil fertility.

Fungus-Proof Paints, Tests Covered in New Bulletins

Fungus-proof paints, and chemicals for achieving them, are subjects of two recent bulletins. The first, a Government publication, is an outgrowth of an Army project to develop a mold-resistant paint for use in tropical climates. Investigators developed a new laboratory test which they say is rapid and which gives results that can be duplicated. The test is described in the report, along with results of tests of some 80 fungicidal chemicals.

The second bulletin reviews several chemicals which protect paints and painted surfaces against mildew and mold. Methods are suggested for utilizing them to preserve water base paints, latex and other emulsion paints, and both natural and synthetic oil paints.

TECHNICAL DEVELOPMENTS

Information about manufacturers of these items may be obtained by writing U. S. I.

A new sealing compound for boats, windows, concrete cracks, etc., contains no asphalt or tars, is claimed to be a permanently pliable product which "sticks to anything" without cracking, chipping, or drying out. **(No. 920)**

Can you use colloidal sodium in your chemical processes? New techniques make the metal available in layers 1 to 5 atoms thick on free-flowing inert carriers. Advantages include faster, safer, more easily controlled reactions. **(No. 921)**

One quart of a new sludge solvent per 1000 gallons of fuel oil is claimed to keep sludge dissolved in the oil, thereby keeping burner tips and screens cleaner and improving combustion. **(No. 922)**

To bleach the natural color from all types of wood, a new compound is available which is quick acting, requires no neutralization, leaves no deposit, and does not raise the grain or warp, the manufacturer states. **(No. 923)**

Kits containing interlocking plastic bricks and model accessories have been introduced for hobbyists, potential home-builders, and architects interested in scale models of houses. **(No. 924)**

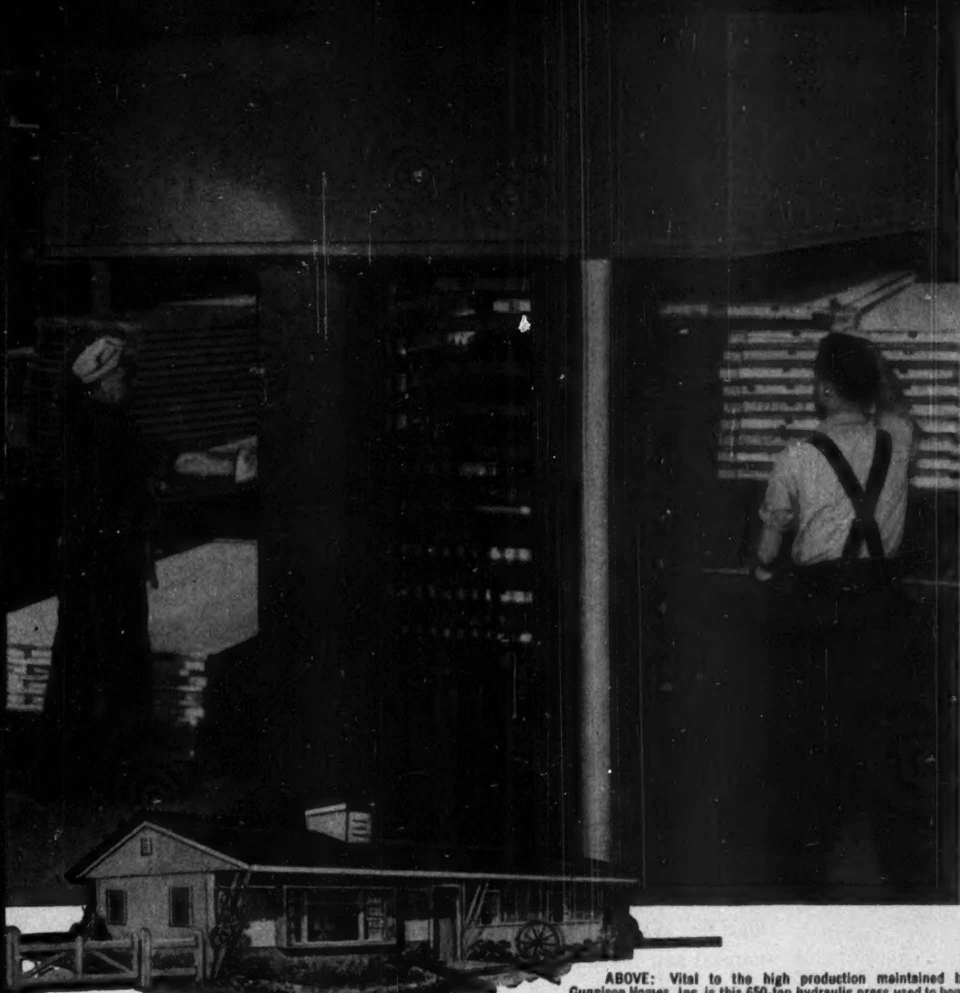
Increased resistance to chemicals at elevated temperatures is claimed for a new synthetic hard rubber compound, available as pipe, fittings, sheets, rods, tubes, and molded parts. **(No. 925)**

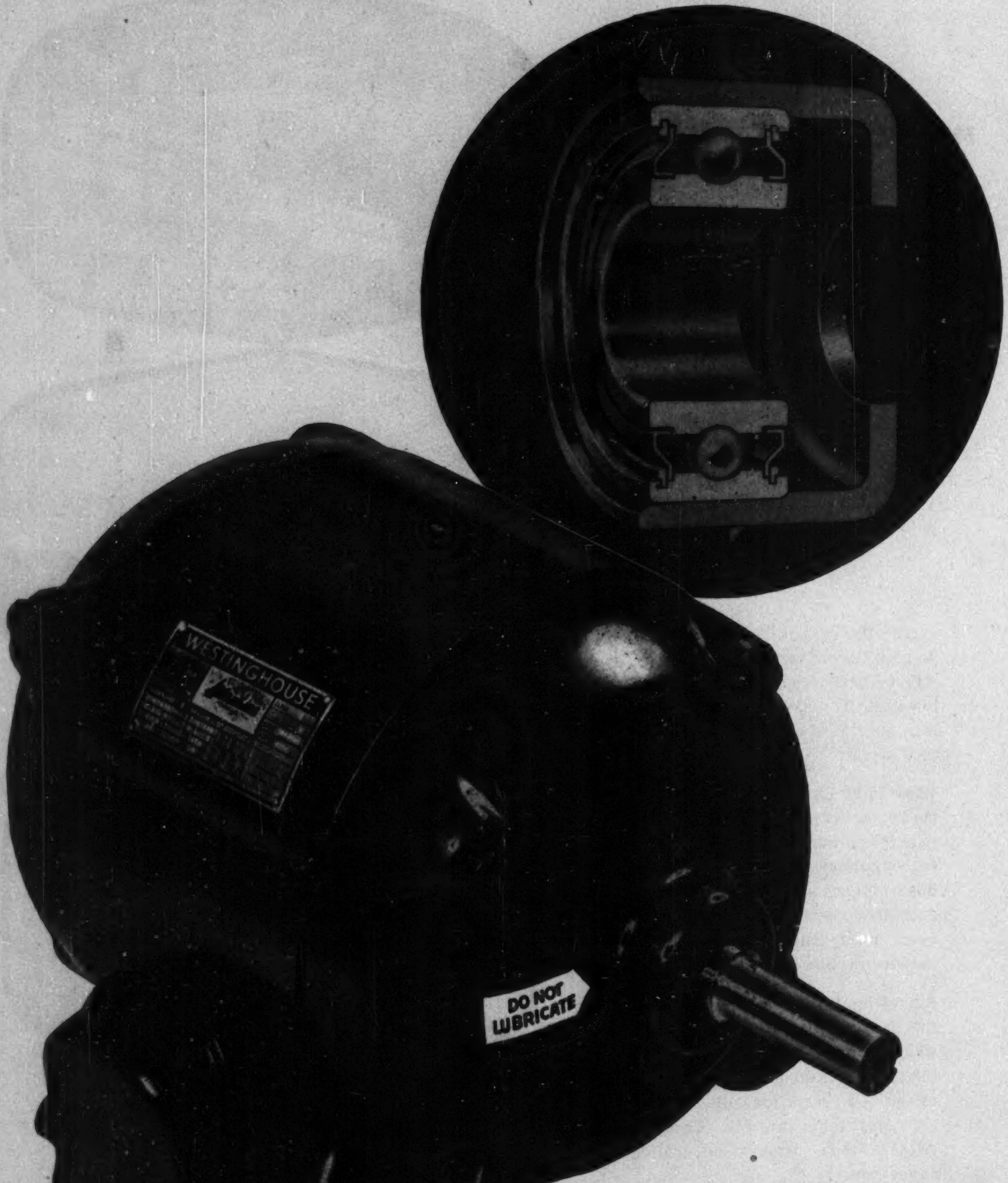
A heavy bodied emulsion-type adhesive has been developed for adhering transparent rubber hydrochloride films to porous surfaces such as Kraft, glassine and other papers and boards, according to the manufacturer. **(No. 926)**

As a complete or partial substitute for Carnauba wax, a new synthetic is said to compare favorably in gel formation and film hardness, and to have added advantages of uniformity, toughness, flexibility, and lower cost. **(No. 927)**

A new glass fabric which stretches while the yarns remain stable has been developed for use as a base for reinforced, low-pressure molded plastic products having compound curves. **(No. 928)**

A surfacing material for interiors of chemical, metal, and food plants, when troweled on concrete, is said to cure to a hard, dense, stonelike, corrosion-proof surface, resistant to solvents, acids, and alkalis. **(No. 929)**





WHAT *Life-Lines* REALLY DELIVER IS MORE SERVICE...LESS SERVICING

How to spot a truly pre-lubricated motor

You are looking at the first motor made to utilize pre-lubrication to its *utmost.* Notice the bearing hub. It was *designed* for a pre-lubricated bearing. There are *no* grease fittings or plugs. The way to grease this modern motor is *don't.*

Westinghouse—the pioneer in pre-lubricated motors—announced in 1948, after 15 years of tests in the laboratory and on the job throughout industry, that Life-Line motors needed no further lubrication. That meant what it said; still means it. You don't have to lubricate them in six months or six years. You don't have to lubricate them—period!

This means you can't grease a Life-Line motor incorrectly. No chance to push dirt into bearings . . . to force grease through seals and into windings. No chance for greasing errors at all! Lubrication problems are out.

So be sure you get a truly pre-lubricated motor. Look for one that has no grease fittings. You'll know then it means what it says and needs no greasing attention. You'll find your answer in Life-Lines. Remember this is but one reason why Life-Lines offer you more service on the job . . . less servicing.

Ask your Westinghouse representative about other reasons—all steel construction and greater electrical strength. And ask for a free copy of "Facts on Pre-Lubricated Bearings" (B-4378), or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-21705-A

YOU CAN BE SURE...IF IT'S

Westinghouse

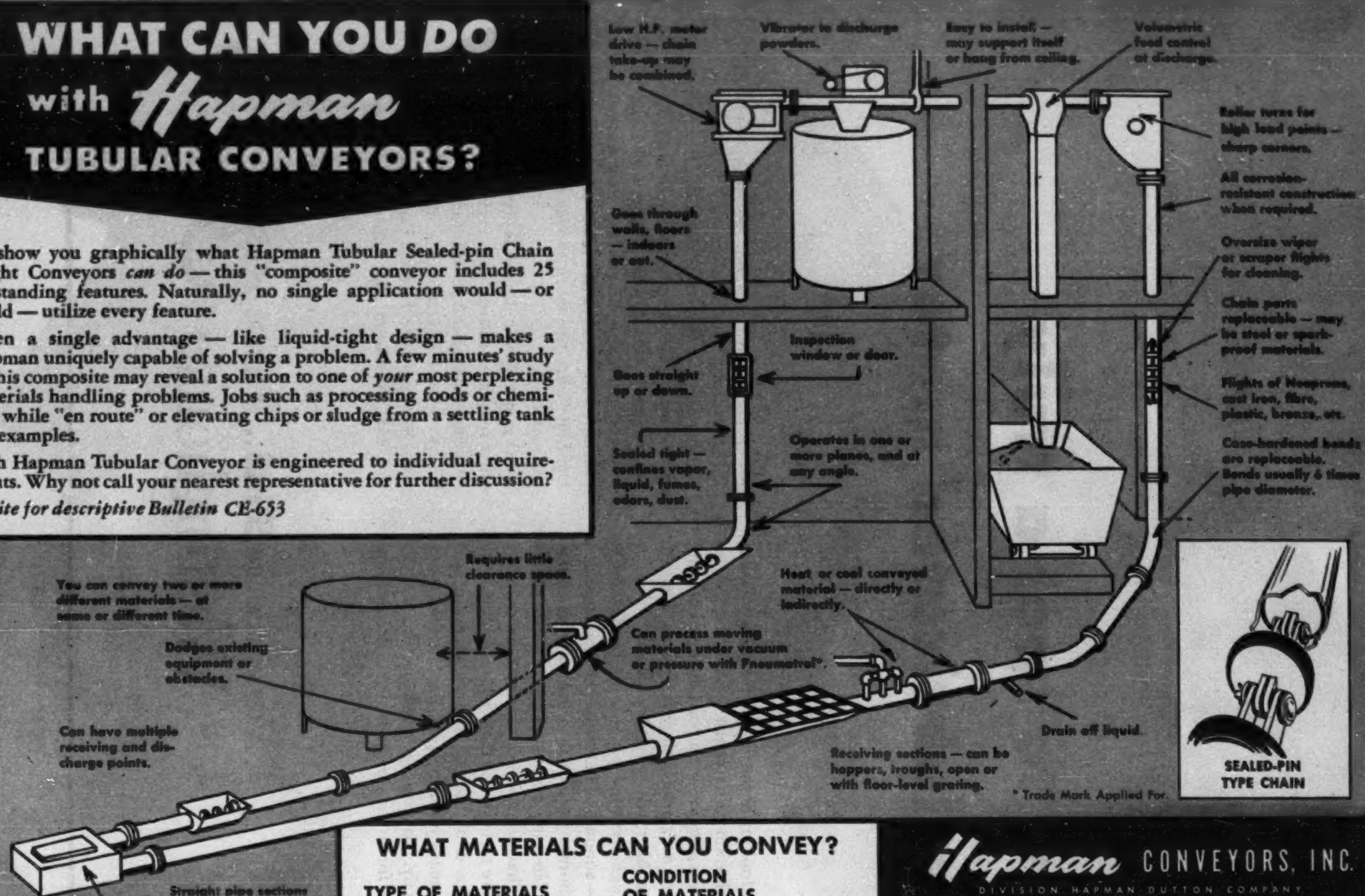
WHAT CAN YOU DO with *Hapman* TUBULAR CONVEYORS?

To show you graphically what Hapman Tubular Sealed-pin Chain Flight Conveyors *can do* — this "composite" conveyor includes 25 outstanding features. Naturally, no single application would — or could — utilize every feature.

Often a single advantage — like liquid-tight design — makes a Hapman uniquely capable of solving a problem. A few minutes' study of this composite may reveal a solution to one of *your* most perplexing materials handling problems. Jobs such as processing foods or chemicals while "en route" or elevating chips or sludge from a settling tank are examples.

Each Hapman Tubular Conveyor is engineered to individual requirements. Why not call your nearest representative for further discussion?

Write for descriptive Bulletin CE-653



WHAT MATERIALS CAN YOU CONVEY?

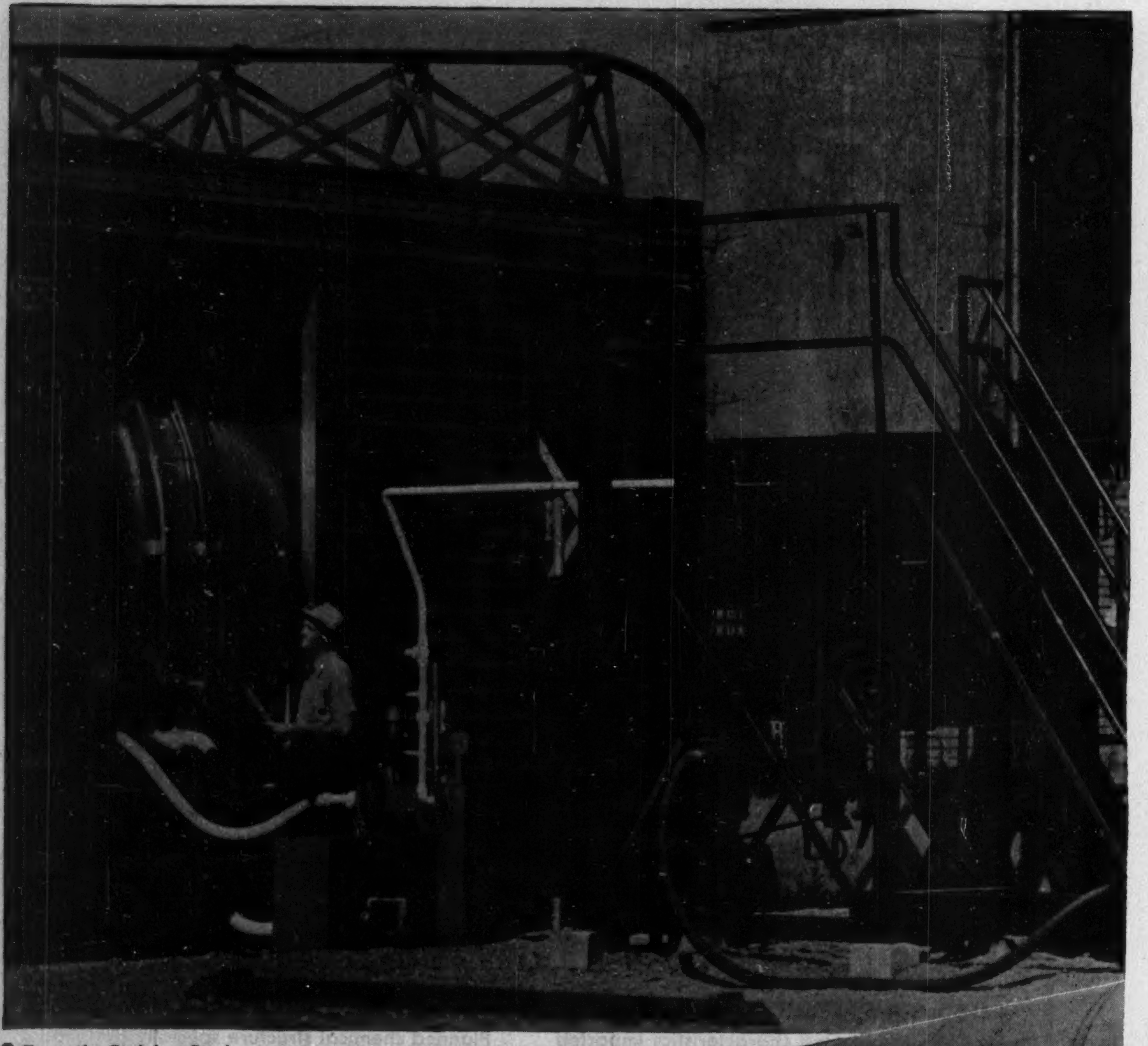
TYPE OF MATERIALS

POWDERS CRYSTALS GRANULAR
LUMPS METAL CHIPS DUSTS
SLUDGES FLAKES

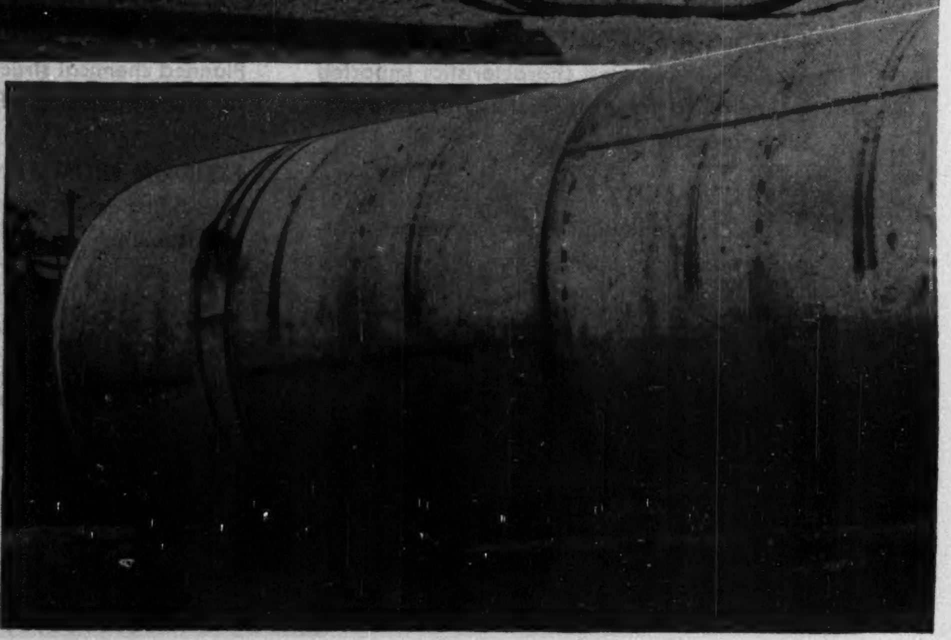
CONDITION OF MATERIALS

WET • DRY • SEMI-LIQUID • HOT • COLD • STERILE • ABRASIVE • CORROSIVE • VOLATILE • EXPLOSIVE • RADIOACTIVE

Hapman CONVEYORS, INC.
DIVISION HAPMAN DUTTON COMPANY
KALAMAZOO MICHIGAN



● From the Stainless Steel tank inside this railroad box car, liquid oxygen is being delivered to a storage tank. Linde Air Products Company, New York, N. Y., uses this method for delivery of both liquid oxygen and liquid nitrogen.



● Here is one of the Stainless Steel tanks of the type used by Linde Air Products Company for this service. This type of tank is installed in a box car, surrounded by powder insulation and a carbon steel shell.

At temperatures down to minus 297°F. and minus 320°F.

Linde Air Products Company ships liquid oxygen and nitrogen in tanks of Stainless Steel

Because Stainless Steel retains its strength and ductility at extremely low temperatures, Linde Air Products Company, New York, has put it to good use in solving the problem of rail shipment of oxygen and nitrogen in the liquid state.

Tanks of Stainless Steel, surrounded by powder insulation and an outer carbon steel shell, are each enclosed in a railroad box car. Equipment is designed so that heat loss and evaporation from tanks is very low.

Temperature of liquid oxygen is minus 297° F. and the conversion factor from liquid to gas is about 862 to 1. Thus the tanks hold a gaseous equivalent of 750,000 to 1,000,000 cubic feet.

When tanks are in liquid nitrogen service, they must hold a liquid that boils at minus 320° F. at atmospheric pressure.

There are many jobs like this in the handling and processing of chemicals where Stainless Steel is the most suitable material obtainable. For, in addition to very high strength, Stainless offers you superior corrosion resistance, freedom from contamination, ease of cleaning and minimum maintenance.

If you have a "trouble spot" anywhere along your production line, ask our representatives to look into the situation. More than likely they'll be able to recommend a grade of perfected, service-tested U·S·S Stainless Steel to correct it.

UNITED STATES STEEL CORPORATION, PITTSBURGH
AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
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U·S·S STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS
PIPE · TUBES · WIRE · SPECIAL SECTIONS

3-871

UNITED STATES STEEL

MOVING TOWARD NEW SOLUTIONS*

Working out new and varied solutions to old problems

is a fundamental part of Niagara's service to industry

NIALK® Carbonate of Potash

With its increased solubility and superior lubricating properties, NIALK Carbonate of Potash is widely used as a dye extender in printing pastes for the finest of printed fabrics.

Backed by constant research, produced with the strictest attention to quality control, this NIALK product—like every NIALK product—meets industry's most exacting specifications.

NIAGARA ALKALI COMPANY

60 East 42nd Street, New York 17, New York

* NIALK LIQUID CHLORINE · NIALK CAUSTIC POTASH

NIALK CARBONATE OF POTASH · NIALK PARADICHLOROBENZENE

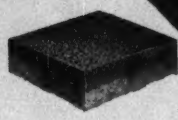
NIALK CAUSTIC SODA · NIALK [illegible]ethylene*

NIAGATHAL · TETRACHLORO PHTHALIC ANHYDRIDE

TOUGH FLOORS
FOR TOUGH CONDITIONS

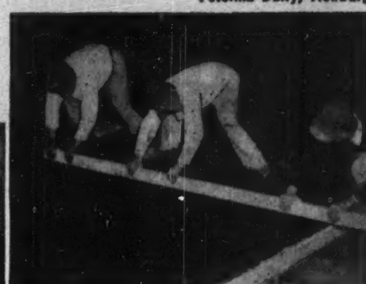
FEREM FLOORS

BLUE TEMPER



Petellas Dairy, Newburgh, N. Y.

These dense, slip-resistant heavy duty floors show no noticeable wear and involve practically no upkeep costs, even under abrasive traffic and shock. Such concrete floors are constructed with Ferem, the "Blue Temper" component in the floor topping (replacing sand, stone and silica). For heavy duty floors, loading platforms, etc., in newly constructed buildings, or when replacing damaged concrete areas. Ferem is resistant to corrosive solutions and the wet floor conditions of many industries.



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Pacific Screw Products Corp., Los Angeles

A. C. HORN CO., Inc. est. 1897

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Long Island City 1, N. Y.
Please send me ☐ complete data on FEREM FLOORS
☐ free copy of your 106-page Construction Data Handbook

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CCI

Consolidated announces an additional service to Southwestern users of Sulphuric Acid

To help Southwestern industries dispose of their spent sulphuric acid, Consolidated Chemical Industries Inc. has recently placed in operation at Baton Rouge, Louisiana, the largest sulphuric acid sludge burning unit ever built. This addition now permits Consolidated to decompose—and make strong new acid from—approximately 1000 tons of spent sulphuric acid per day.

The disposal of spent acid has become an increasingly serious problem for oil refineries and process industries. Many users have been forced to operate acid concentrators. Also, certain sludge disposal practices have greatly increased air pollution problems for acid users.

Consolidated's new facilities substantially eliminate the acid disposal problems of a number of Southwestern users.

The need to operate concentrators is reduced. Sulphur waste is minimized and air pollution by sulphur dioxide is reduced. Most important, the economics of handling spent acid in this manner is comparable to older forms of disposal.

We, at Consolidated, are constantly searching for better ways to serve users of heavy chemicals. We are proud of the part we have played in helping our customers solve their problems.

Consolidated Chemical Industries Inc.

SAN FRANCISCO • HOUSTON • NEW YORK

PROCESS PUMPS

Here's Why An Allis-Chalmers Complete Pumping Unit Is

Your Best

Allis-Chalmers Type APKK explosion-proof motor. Fin-type design with no enclosed passages for external cooling air. Cannot clog and overheat. If cleaning is required, it takes only a few minutes with cloth, brush, vacuum or air hose. All cast-iron frame resists corrosion. Similar design available in totally-enclosed, fan-cooled motors for non-hazardous locations.

Allis-Chalmers oil-lubricated, frame-type pump. Will handle many process jobs at less cost than usual refinery pump. Available with capacities to 1200 gpm, heads to 250 feet and temperature range to 550 F. Built with wide choice of materials to handle many types of corrosive liquids. Can be provided with six different sealing arrangements, including mechanical seal and water-cooled stuffing box. As you can see from the picture, there is plenty of room between the pump and the bearing for maintenance.

Send for Free Engineering Literature

Motors

- ☐ Handy Guide to Motor Selection 51B6052
- ☐ Explosion-proof Motors (APZZ) 51B7286
- ☐ Explosion-proof Motors (AZZ) 51B7149

Pumps

- ☐ Handy Guide to Pump Selection 52B6059
- ☐ Oil-Lubricated, Frame-type Pumps 52B7638

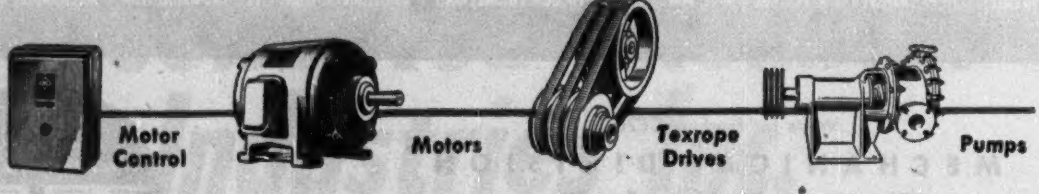
Control

- ☐ Handy Guide to Starters 14B7733
- ☐ Reduced Voltage Starters 14B7215

Texrope Drives

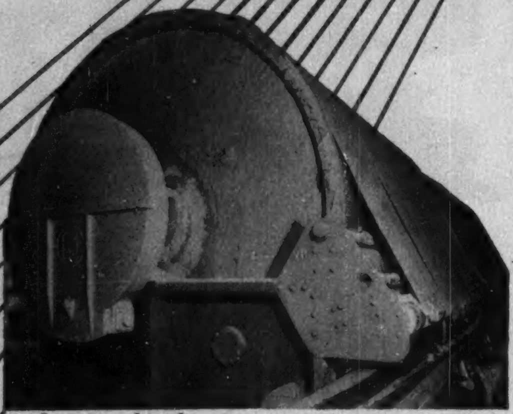
- ☐ Handy Guide to *Texrope* Drives 20B6051

COMPLETE SERVICE *from power line to machine*

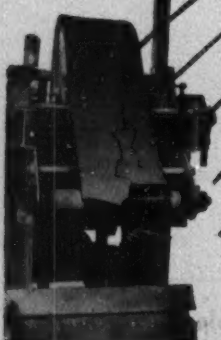


YOU CAN PUT ALMOST ANY FILTER CAKE ON STRINGS

STICKY GELS



THIN SLIMES



HEAVY SLUDGES

The famous FEinc String Discharge handles almost any type of cake . . . thin, soupy slimes . . . heavy or coarse granular materials . . . or sticky gels. In every case, the cake is *lifted* cleanly from the cloth, with no scraper to smear, plug, and wear the fabric. Cloths last two to five times longer . . . and lighter, more efficient weaves can be used.

Other FEinc features back up this performance. The FEinc compression dewatering mechanism removes 2% to 6% more moisture from the cake. If washing is necessary, the FEinc submergence type washing mechanism, with a compression belt to close up cracks and prevent "channeling" of the wash water, washes out more solubles with less dilution.

Whether you're after a clean dry cake, or high soluble recovery with minimum dilution . . . and regardless of the consistency of your cake . . . write us today for more details. Ask for Technical Bulletin 103.

FILTRATION ENGINEERS INC.

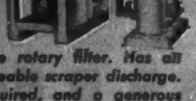
155 ORATON STREET • NEWARK 4, NEW JERSEY

HOW TO LEARN MORE ABOUT FEinc FOR YOUR PROCESS....

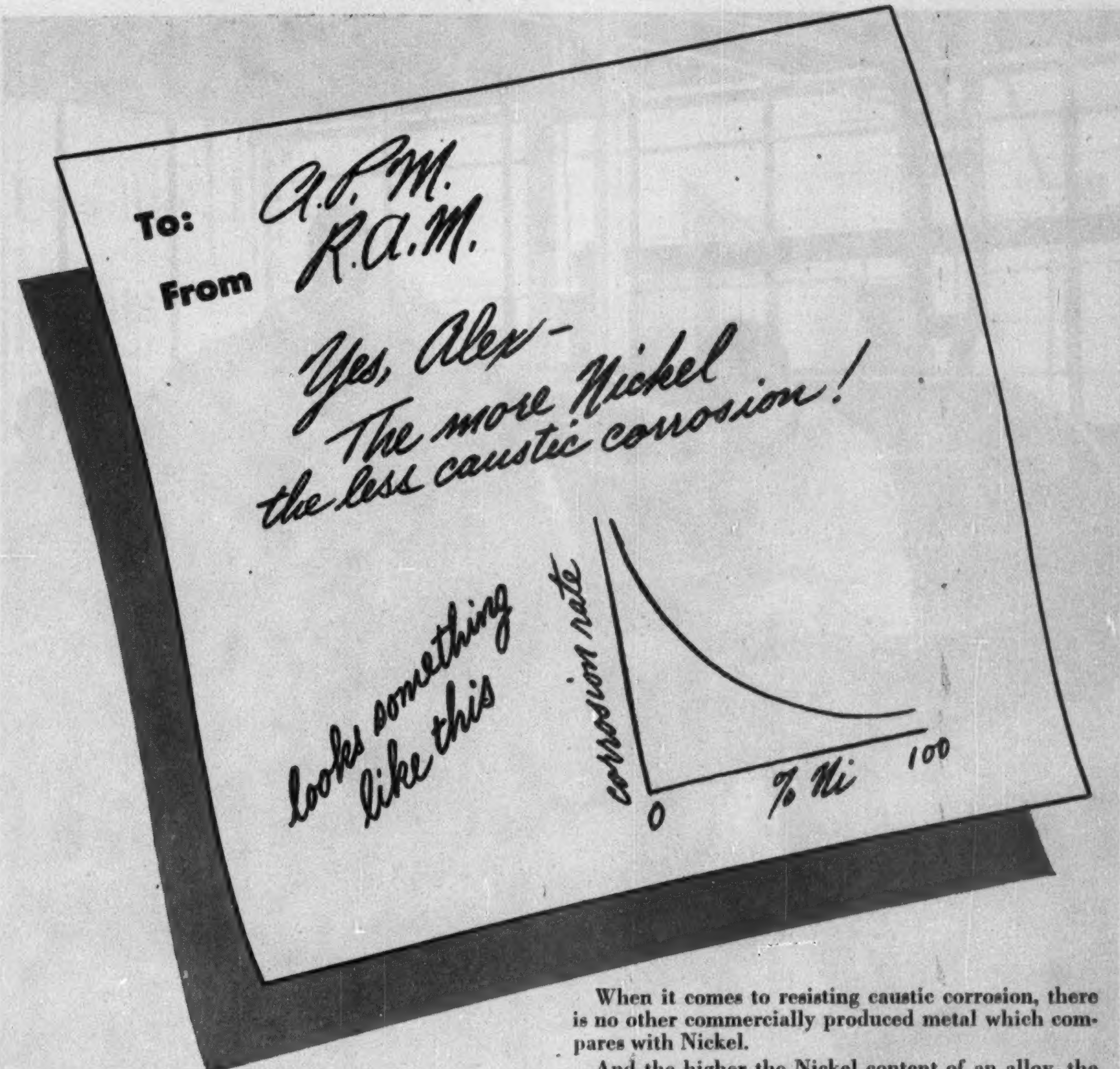
1 FREE TESTING SERVICE

At no expense to you, we'll test your slurry and send you a complete report on what FEinc filters can do for you. In your plant, without interrupting your process, or in our laboratory, with a 5-gallon sample of your slurry. Send it today!

2 PILOT PLANT FILTER



RENT this small but complete rotary filter. Has all FEinc features, plus interchangeable scraper discharge. No capital investment is required, and a generous part of the low monthly rental can be credited against the future purchase of any FEinc filter. Write today for details.



When it comes to resisting caustic corrosion, there is no other commercially produced metal which compares with Nickel.

And the higher the Nickel content of an alloy, the lower the corrosion rate will be.

That's why, when you consider caustics you should consider Nickel and the Inco Nickel Alloys.

Inco Nickel Alloys are produced in mill forms and as Lukens Clad Steel.

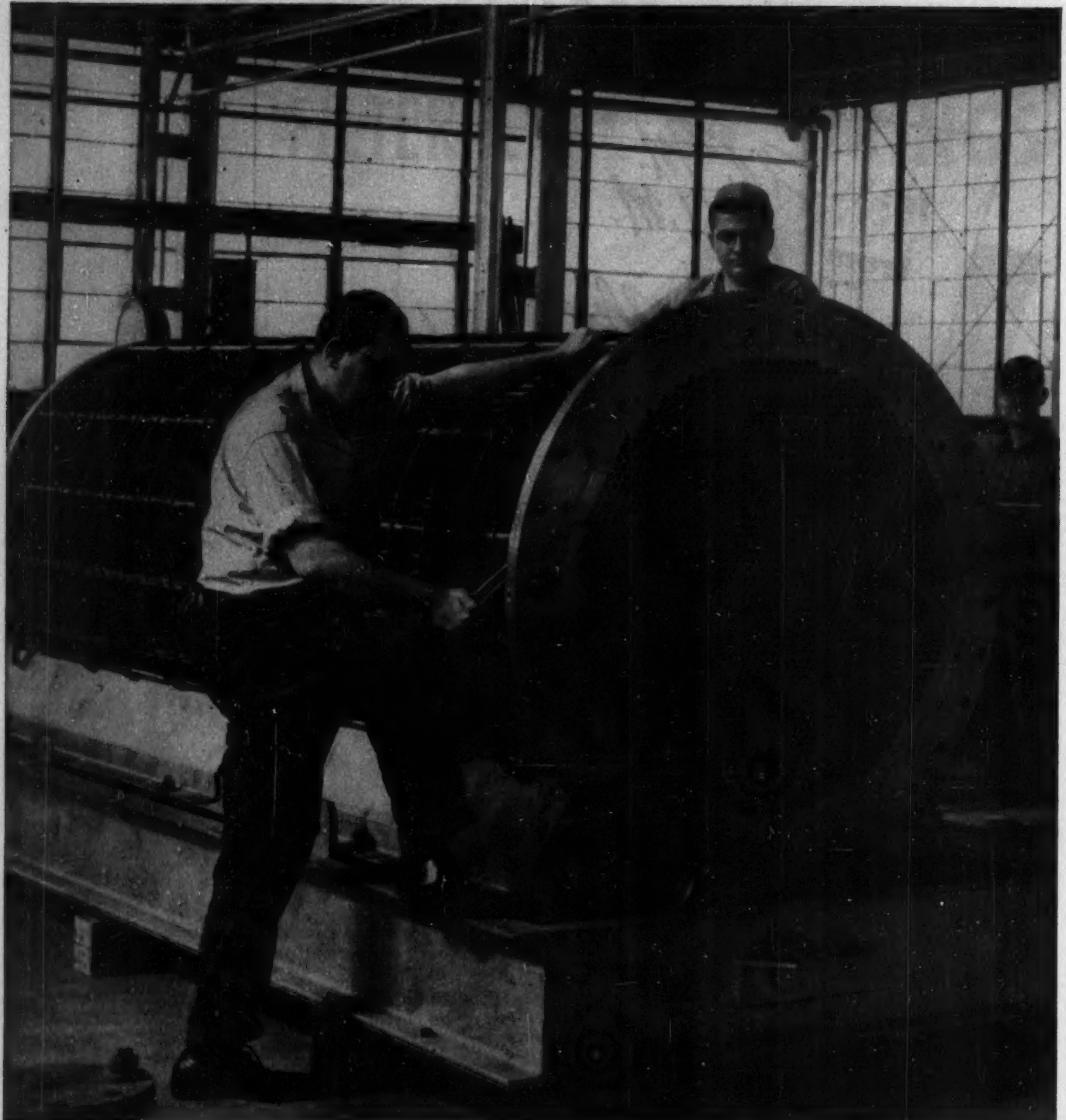
Of course, there is no one metal or alloy which solves all caustic corrosion problems. That's why it will pay you to consult Inco's Corrosion Engineering Section when you want a specific solution to your problem. They have a wealth of information and will be glad to advise you.

It is advisable to place equipment orders with your supplier well in advance of scheduled use. Distributors of Inco Nickel Alloys can supply the latest information on availability from warehouse and mill. The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.

INCO TRADE MARK

Inco Nickel Alloys

MONEL® • "R"® MONEL • "K"® MONEL • "KR"® MONEL
"S"® MONEL • INCONEL® • INCONEL "X"® • INCONEL "W"® • INCOLOY®
NIMONICS® • NICKEL • LOW CARBON NICKEL • DURANICKEL®



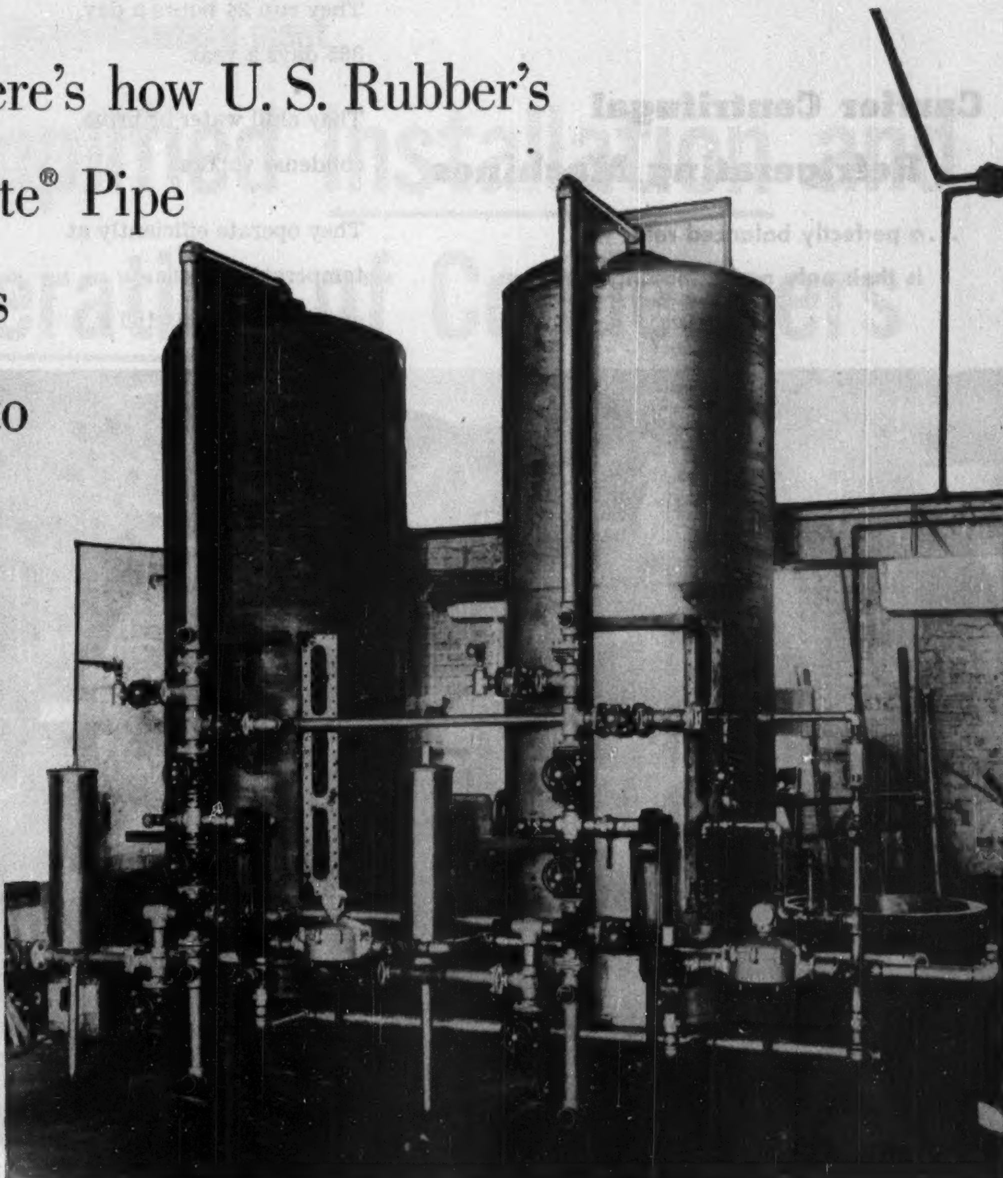
This Gas Cooler, made by a well-known manufacturer of heat exchangers, is designed to bring gas down from 250°F. to 80°F.

The job called for inhibited admiralty... and ANACONDA Arsenical Admiralty-439 was chosen for the tubes in this new gas cooler. Highly resistant to dezincification due to its arsenic content, this alloy can handle corrosive cooling waters at high temperatures. It's economical—a standard alloy for refinery condensers and heat exchangers handling crudes, re-run stocks, cracked products, lubricating oils and by-products. In this cooler, tube sheets are ANACONDA Ambraloy-917 Aluminum Bronze; baffle plates are ANACONDA Manganese Bronze; and spacer rods are ANACONDA Naval Brass Rod. All were supplied by The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

• • • We have a large file of case histories. In selecting tube alloys, take advantage of this wealth of experience. Consult our Technical Department. It's a free service. 53118

for efficient heat transfer ANACONDA® HEAT EXCHANGER TUBES

Here's how U. S. Rubber's Uscolite® Pipe fits into this



water-conditioning picture!

Uscolite plastic pipe and fittings fit to a "T" the rigid specifications of these de-ionization units—part of the Illinois Water Treatment Company's extensive operation. The caustic soda and sulphuric acids never corrode Uscolite. And Uscolite non-swelling pipe and fittings do not contaminate the water. The pipe is used both inside and outside the unit.

Uscolite will amaze you by its extremely high impact strength. It is loaded with endurance, needs minimum maintenance on the job. Next time you need piping, you can't do better than Uscolite. Write to address below for full information.

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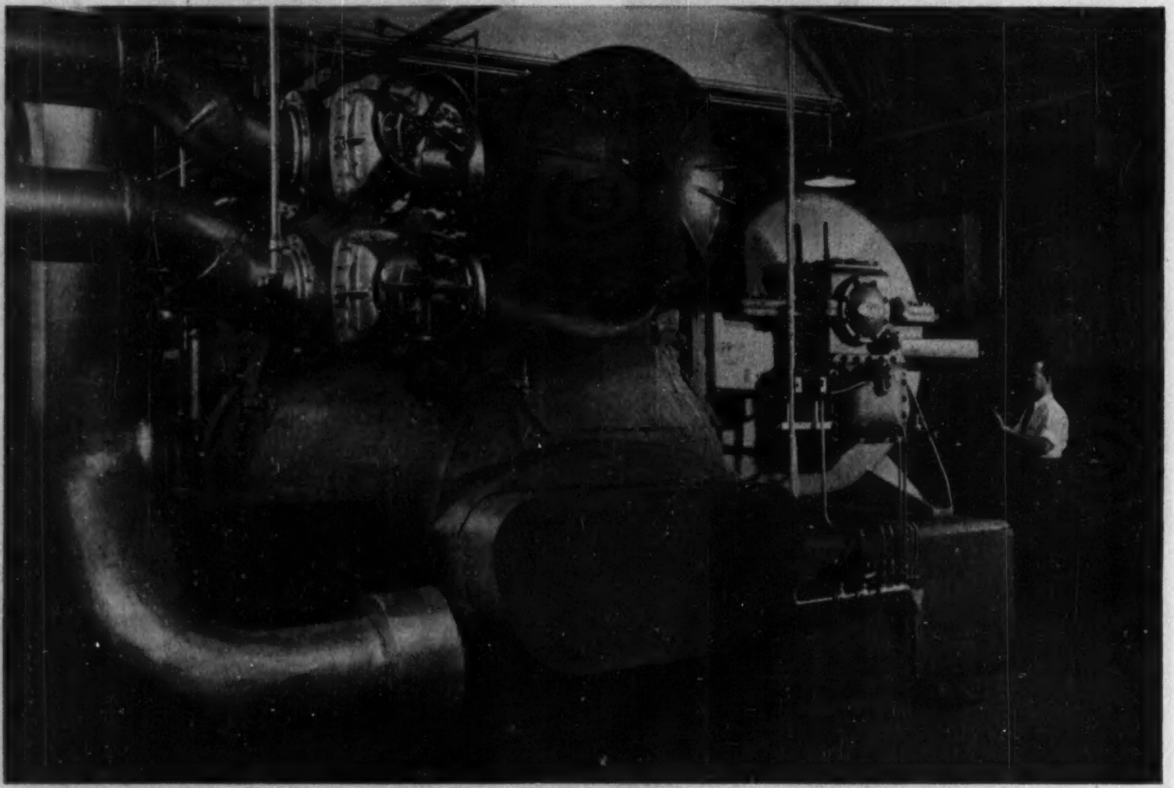
Carrier Centrifugal Refrigerating Machines

...a perfectly balanced rotor is their only major moving part

They run 24 hours a day, 365 days a year.

They chill water or brine, condense vapors.

They operate efficiently at temperature levels even below minus 150 F.



They control critical process temperatures accurately, automatically.

They employ steam turbine or electric motor drive.

They serve many of the world's largest chemical plants.

For informative catalog write Carrier Corporation, Syracuse, New York.

Carrier

air conditioning · refrigeration industrial heating

How a pharmaceutical plant

Simplified Installation and Operation of Condensers

with "Delanium" Carbon Cubic Exchangers

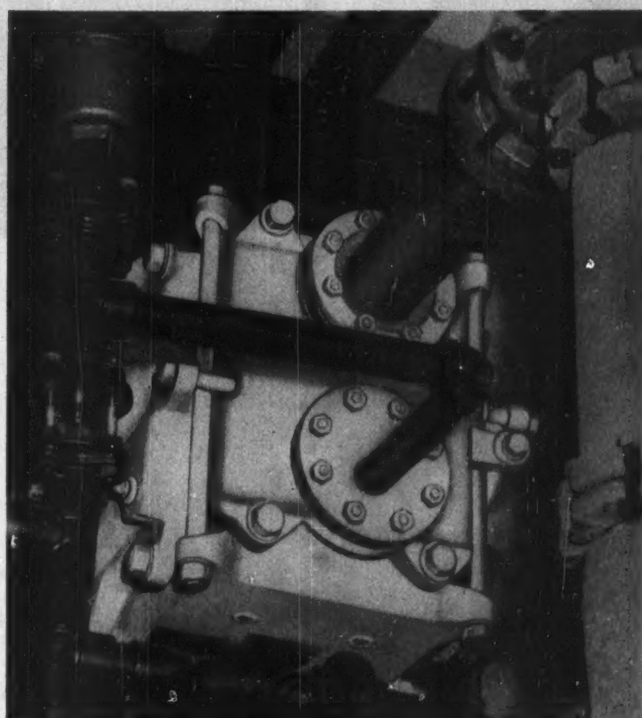
HOFFMANN-LAROCHE, world-famous producers of pharmaceuticals, selected "Delanium" Carbon Cubic Heat Exchangers for their important condenser installations. Here's why:

First, the "Delanium" exchangers withstand highly corrosive process vapors—HCl in several applications and halogenated ketones in others. Actually, the dense, impervious "Delanium" graphite resists attack of most acids, alkalies, salt solutions and organic chemicals.

Also, these units are exceptionally compact—50 sq. ft. of high heat transfer surface in a 15 inch cube. In fact, "Delanium" units require only about one-tenth the space of shell-tube type condensers, thus permitting installation close to other equipment in the system and saving long runs of costly corrosion-proof pipe. Only simple supporting ceiling hangers are needed.

Furthermore, the design permits operation of the units under vacuum higher than 100 microns. In all installations, these units provide for complete drainage, subcooling the condensate, and zero hold-up of the product.

Write for this fact-filled bulletin. It gives detailed design specifications and operating characteristics.



This Hoffmann-LaRoche installation is an example of how the compact "Delanium" exchanger can be placed at the most efficient location—even where space is limited.

The simplicity of the "Delanium" design **provides an exchanger with exceptional adaptability to widely different processes. It also is being successfully used—**

- **as a Heater**
- **as a Cooler**
- **as an Evaporator**
- **as a Crystallizer**
- **as a Reaction Vessel**

...with all these operating advantages:—

HIGH PRESSURES—Graphite cube clamped in compression by heavy castings permit operating to 100 psi.

HIGH HEAT TRANSFER—Accurately designed cube insures high heat exchange.

LOW MAINTENANCE—All headers easily removed for inspection, cleaning. No fragile tube bundles.

HIGH CORROSION RESISTANCE—Corrosives contact only "Delanium" graphite.

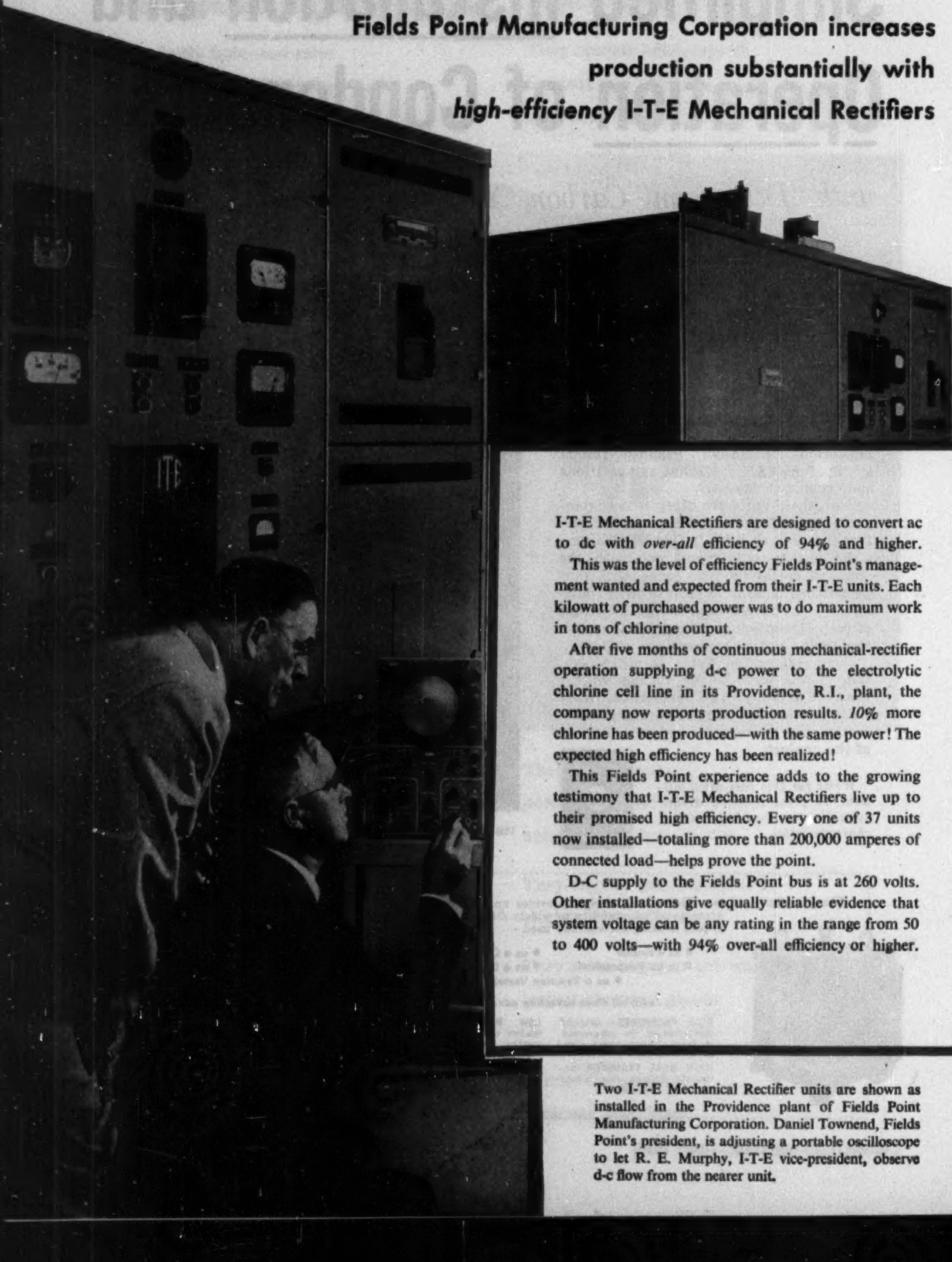
"Delanium"
Trade Mark

Delanium Carbon Corporation
18 East 48th St., New York 17, N. Y.

In England: Powell Duffryn Carbon Products Ltd., Hayes, Middlesex, England

The same incoming power

Fields Point Manufacturing Corporation increases production substantially with *high-efficiency* I-T-E Mechanical Rectifiers



I-T-E Mechanical Rectifiers are designed to convert ac to dc with *over-all* efficiency of 94% and higher.

This was the level of efficiency Fields Point's management wanted and expected from their I-T-E units. Each kilowatt of purchased power was to do maximum work in tons of chlorine output.

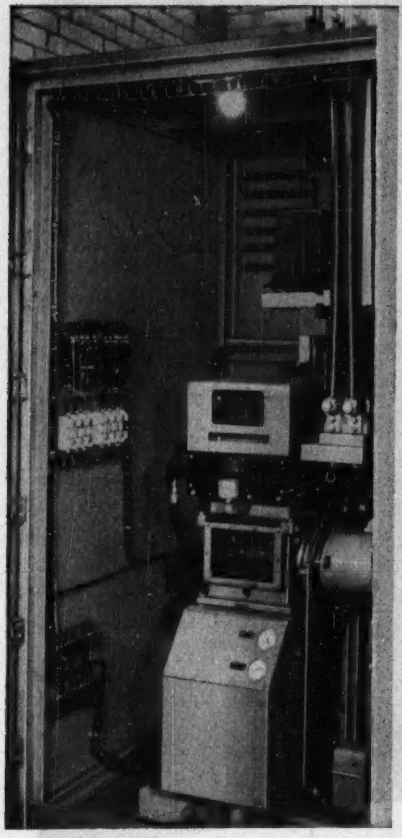
After five months of continuous mechanical-rectifier operation supplying d-c power to the electrolytic chlorine cell line in its Providence, R.I., plant, the company now reports production results. *10%* more chlorine has been produced—with the same power! The expected high efficiency has been realized!

This Fields Point experience adds to the growing testimony that I-T-E Mechanical Rectifiers live up to their promised high efficiency. Every one of 37 units now installed—totaling more than 200,000 amperes of connected load—helps prove the point.

D-C supply to the Fields Point bus is at 260 volts. Other installations give equally reliable evidence that system voltage can be any rating in the range from 50 to 400 volts—with 94% over-all efficiency or higher.

Two I-T-E Mechanical Rectifier units are shown as installed in the Providence plant of Fields Point Manufacturing Corporation. Daniel Townend, Fields Point's president, is adjusting a portable oscilloscope to let R. E. Murphy, I-T-E vice-president, observe d-c flow from the nearer unit.

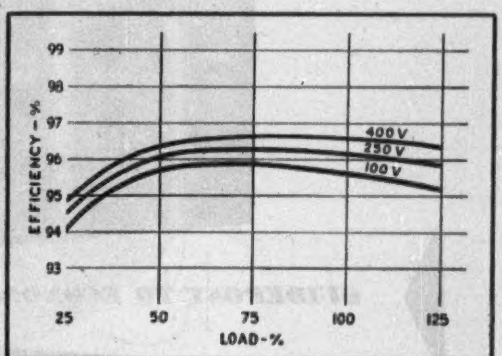
but 10% more chlorine!



HIGH EFFICIENCY THROUGHOUT LOAD RANGE

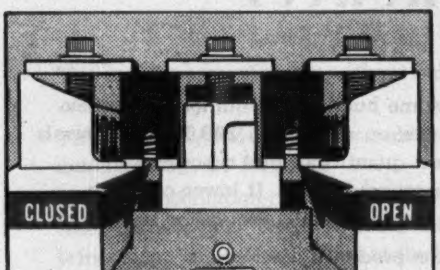
During continuous operation at the Fields Point plant, load has remained at or very near 100%. Should load vary at any time to as low as 25% or up to 125%, over-all conversion efficiency will still be high. The LOAD-EFFICIENCY curve below is characteristic of I-T-E Mechanical Rectifier performance, and represents a principal advantage: flexibility for plant production schedules while getting the most out of a-c power purchased.

One of the two contact mechanisms in the Fields Point installation of I-T-E Mechanical Rectifiers. Each Rectifier is a standard I-T-E unit with design rating of 5000 d-c amperes.



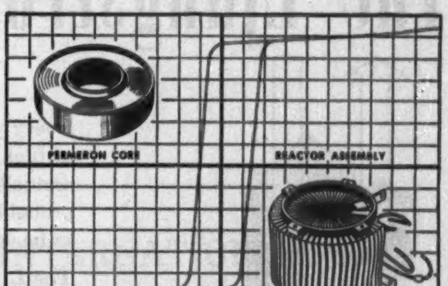
HERE'S WHY

Here are two basic reasons why I-T-E Mechanical Rectifier users get 94 kw (and more) of d-c power for every 100 kw of a-c power they buy:



Solid silver contacts held closed by powerful springs, give highest conductivity between a-c and d-c networks.

Sparkless low-loss commutation is obtained by interposing a Permeron*-core reactor between a-c supply and contact mechanism. This provides a brief period during which current in a contact is zero, allowing sufficient time for sparkless contact closing or opening.



**I-T-E's special saturable core material. Typical Permeron magnetization curve is shown above.*

Get the facts—If you are planning new or expanded a-c to d-c conversion facilities, it will pay you to investigate high-efficiency I-T-E Mechanical Rectifiers. They increase production or cut power bills in many kinds of applications—electrolytic chemical production, metal refining, motor load. Write for details.

BULLETIN 5106—covers theory, design, construction, standard arrangements.

BULLETIN 5204—gives details of I-T-E's special magnetic core material, *Permeron.*

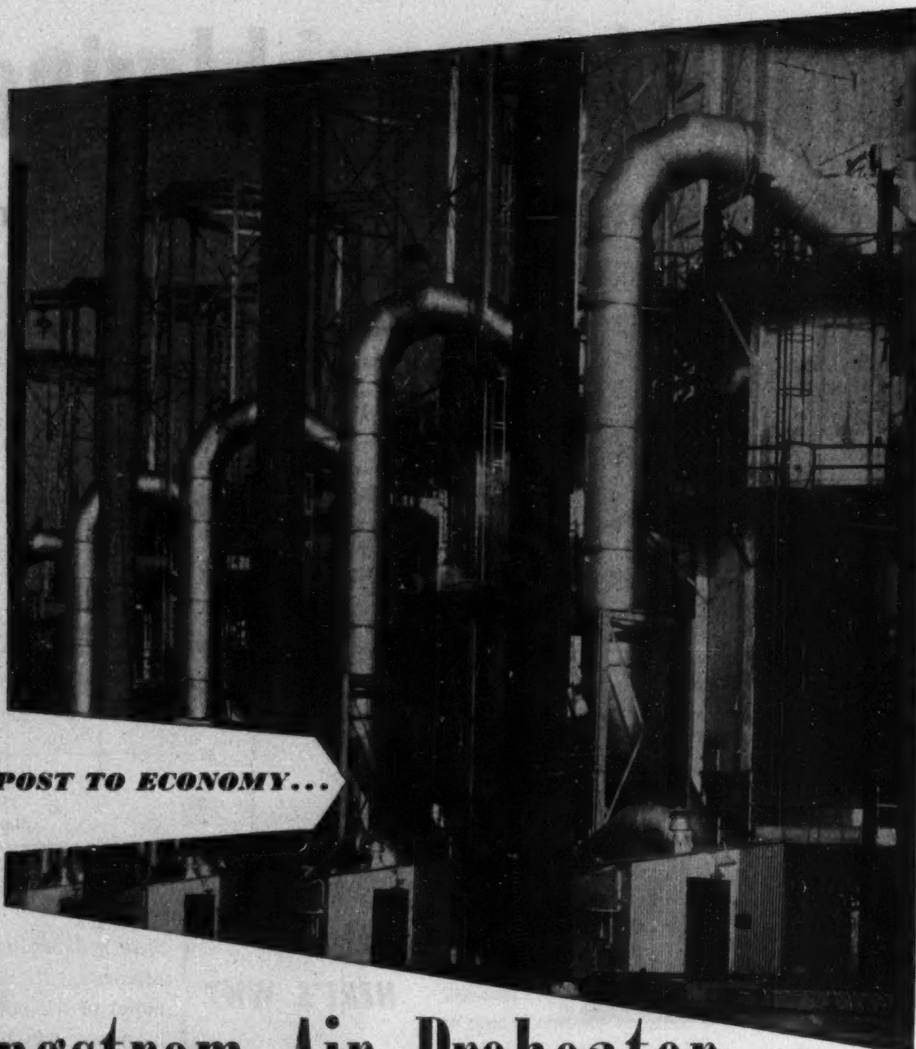
BULLETIN 5205—presents engineering explanation of high efficiency provided by I-T-E Mechanical Rectifiers.

I-T-E

MECHANICAL RECTIFIERS

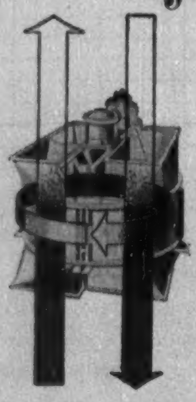
I-T-E CIRCUIT BREAKER CO. • Rectifier Division • 19th and Hamilton Streets, Philadelphia 30, Pa.

EPD—Canadian Mfg. and Sales: Eastern Power Devices, Ltd. Toronto



GUIDEPOST TO ECONOMY...

The Ljungstrom Air Preheater



The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transferred from the waste gases to the incoming cold air.

Every year, the process industries consume hundreds of millions of barrels of fuel. Refineries alone, for example, use up more than 200,000,000 barrels annually for processing crudes. This vast quantity of fuel represents probably the *greatest single item* in operating expense. If lower costs are to be realized, serious thought must be given to heat-conservation equipment.

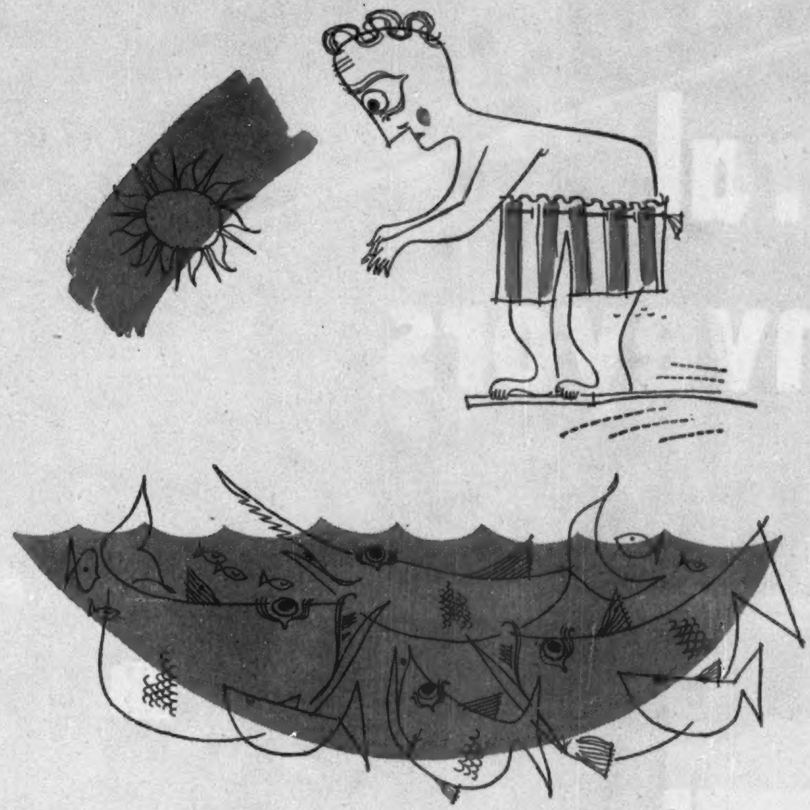
The Ljungstrom Air Preheater offers the process industries a chance to save as much as *20% of the fuel needed for process work.* This fuel saving, plus the added benefit of increased production, makes the Ljungstrom an eminently practical piece of equipment to be considered wherever fuel is burned.

Check today to see how the Ljungstrom Air Preheater will pay for itself in just a few months — and give you impressive savings for years to come. Call or write The Air Preheater Corporation for full details.

Wherever You Burn Fuel, You Need Ljungstrom

THE AIR PREHEATER CORPORATION

60 East 42nd Street, New York 17, N. Y.




spiral
conveyors
A complete line of Flights and Accessories for new and replacement service. A compact conveyor — no return strand — can be made dust-tight.
Catalog No. 803-B

You'll save time and trouble on H.P. VESSEL GASKETS

...when J-M Goetze gasket specialists make them for you

When you need gaskets such as those above, which were made for pressure vessel service over 5000 psi, consider this. It takes less time and trouble to turn the job over to J-M Goetze—an organization that has specialized in gasket design and manufacture for 67 years. And it usually costs less in the long run.

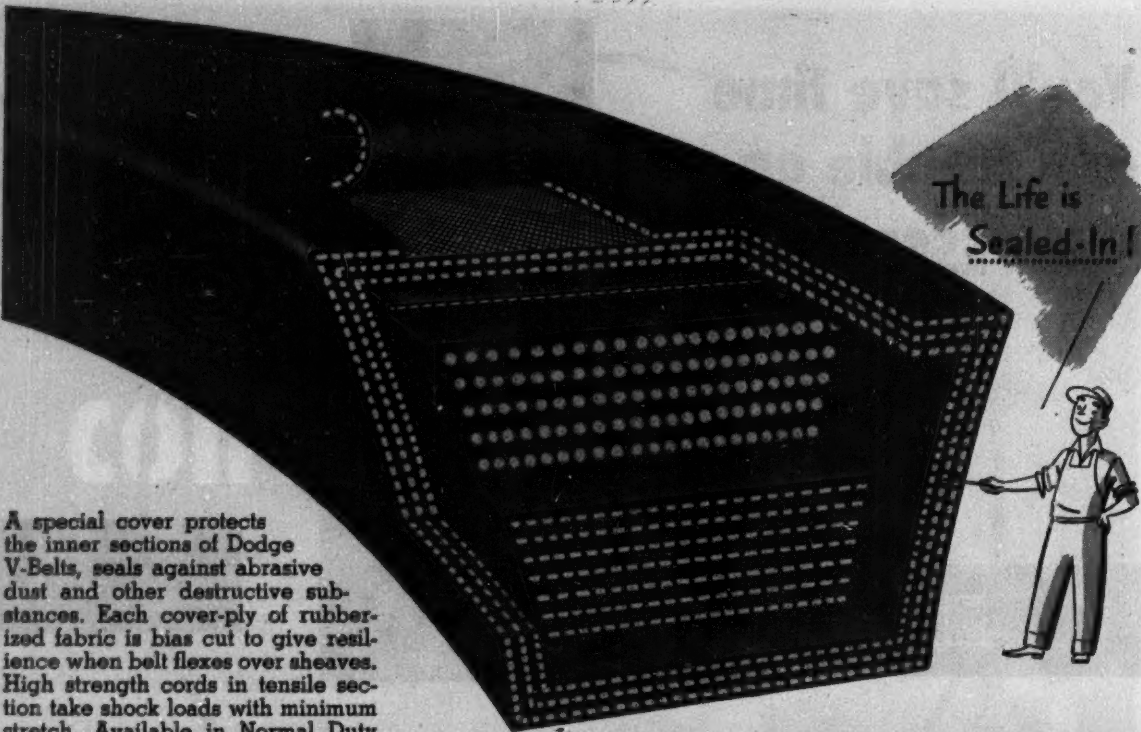
Goetze engineers can select the right style for maximum sealing efficiency. They know the correct metals and other factors required for efficient, long-lasting gaskets.

Goetze Gaskets are made exactly to the last detail of your specifications and conditions. They are made to craftsmen's perfection . . . with modern machine tools, some of which were specially designed by Goetze for gasket manufacture.

If you need gaskets for high pressure vessels or similar applications, send us a drawing or template for quotation. Or write for further information to Johns-Manville, Box 60, New York 16, New York.

Johns-Manville Goetze GASKETS

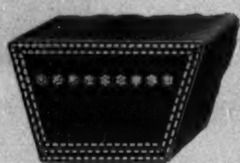
THERE'S A JOHNS-MANVILLE PACKING AND GASKET FOR EVERY SERVICE



A special cover protects the inner sections of Dodge V-Belts, seals against abrasive dust and other destructive substances. Each cover-ply of rubberized fabric is bias cut to give resilience when belt flexes over sheaves. High strength cords in tensile section take shock loads with minimum stretch. Available in Normal Duty type for regular service—and Special Duty type for special service.

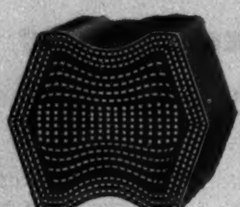
DODGE Sealed-Life V-BELTS

FRACTIONAL HP SEALED-LIFE



Have same basic features found in regular Dodge Sealed-Life Belts—recommended for use in single belt drives within their rated HP capacities—provide a maximum of service.

SEALED-LIFE DOUBLE-V



Virtually two belts molded back-to-back as a single unit. Used in special drives where belt must transmit power to two or more sheaves. Embody all features of regular Sealed-Life Belts.

DODGE CUT-TO-LENGTH V-BELTING

Available in rolls, permitting its use in any desired length by using a fastener. Similar in construction to Sealed-Life Belts except load is carried by multiple plies of woven fabric.

DODGE
of Mishawaka, Ind.

CALL THE TRANSMISSIONEER, your local Dodge Distributor. Factory-trained by Dodge, he can give you valuable assistance on new, cost-saving methods. Look for his name under "Power Transmission Machinery" in your classified telephone directory.

DODGE MANUFACTURING CORPORATION
200 Union St., Mishawaka, Ind.

Taper-Lock Sheaves

Dodge-Timken Bearings

Diamond D and Rolling-Grip Clutches

FOR YOUR NAME PLATE REQUIREMENTS, WRITE OUR SUBSIDIARY, CHICAGO THRIFT-ETCHING CORPORATION, 1555 N. SHEFFIELD AVENUE, CHICAGO 22, ILLINOIS

... than for the blower that keeps men cool

When hot, stagnant or fume-filled air distresses your men, your production suffers too.

Give men around furnaces or hot processes, or in confined areas, a steady supply of fresh, cool air with Coppus Blowers and Exhausters and watch their efficiency jump to a more profitable level.

There's a portable, easily adaptable Coppus "Blue Ribbon" product for practically any fresh-air requirement. The Coppus "Blue Ribbon" is the sign of precision workmanship and trouble-free, long-lasting operation. Check and mail the coupon for exact information. Sales offices in THOMAS' REGISTER. Other "Blue Ribbon" Products in CHEMICAL ENGINEERING CATALOG, REFINERY CATALOG, BEST'S SAFETY DIRECTORY, MINING CATALOGS.

OTHER
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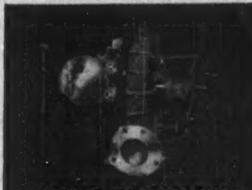
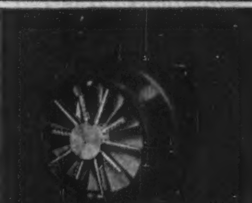
"BLUE RIBBON"
PRODUCTS



HORIZONTAL TURBINE
Six frame sizes —
1 to 150 horsepower

VERTICAL TURBINE
Six frame sizes —
1 to 150 horsepower

FANMIX GAS BURNER



FANMIX GAS-OIL BURNER

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PLEASE SEND ME INFORMATION ON SUPPLYING FRESH AIR TO MEN WORKING:

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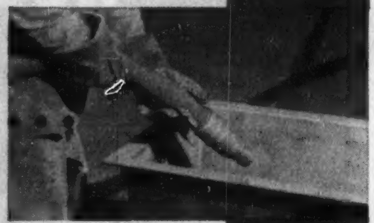
For Lining Tanks

Here's why... Here's how



Tank is sandblasted before lining.

TYGON's outstanding resistance to acids and alkalies permits its use in all the usual lining and covering jobs.

TYGON's unique resistance to oxidizing acids, oils, greases, and solvents makes possible its use in jobs other linings cannot handle.

TYGON's flexibility permits close conformance, resulting in a good bond, to all but the most intricately shaped equipment.

Special cements are used.

TYGON's resilience minimizes the possibility of damage from mechanical abuse.

TYGON's elasticity permits thermal contraction and expansion without rupture.

TYGON's abrasion resistance withstands the wearing action of thick slurries and dry or moist chemicals.

TYGON's negligible extractibility prevents contamination of the most sensitive solutions.

Thick TYGON sheeting is applied.

TYGON's white color (Compound No. TL-104B) permits full solution visibility—facilitates quality control—highlights impurities.

TYGON's high electrical resistivity prevents current losses in electrolytic action.

TYGON's smooth, non-porous surface makes for easier cleaning and greater solution flow.

TYGON's thermoplasticity permits the "heat-sealing" of seams to form continuous, one-piece, impermeable linings.

Joints are "strip-sealed."

TYGON's selective solvent sensitivity eliminates the "need" for curing to obtain a strong bond—makes possible installations of virtually any size—simplifies field repairs.

TYGON's non-oxidizing characteristics give it a long service life.

And remember, Tygon linings can be installed by a licensed Tygon applicator near you—with major savings in time and money.

Entire lining is "spark-tested."

Write, right now, for more information! Ask for our new 12-page booklet on TYGON LININGS—Bulletin TL-526. It's packed with facts and figures.

U. S. STONEWARE

AKRON 9, OHIO

PROCESS EQUIPMENT DIVISION

158-D

THE *Chementator*®

Prepared under the direction of Joseph A. O'Connor, News Editor

• Don't be surprised if Monsanto's hush-hush commercial process for making titanium turns out to be a reduction process using, not magnesium, but sodium amalgam.

• Ionic diaphragm cells, with ion permeable membranes made by Rohm & Haas, are being designed by Hooker Electrochemical. Their first impact will come in the chlor-alkali industry, but they'll be important to pulp and paper makers, producers of acetate and viscose rayon and others.

Taming phosphine to make THPC

Phosphine gas, highly toxic and tough to handle, is the starting material in a new industrial process developed by Oldbury Electro-Chemical of Niagara Falls for the manufacture of tetra-kis-hydroxymethyl phosphonium chloride.

In the Oldbury process, phosphine is reacted with formaldehyde and HCl to produce the THPC. It will be used in a new method developed by the Southern Regional Research Laboratory of the U. S. Department of Agriculture for flameproofing cotton.

The THPC, together with methylol melamine or a urea resin, is applied to the cotton to make it flame-retardant. It may likewise prove useful for other fabrics.

Chlorine dioxide bleaching gives brighter pulp

One of the first large plants in the United States to manufacture its own chlorine dioxide and use it in bleaching pulp to get extra brightness is the big new kraft mill of Riegel Carolina Corp. near Acme, N. C.

The chlorine dioxide is manufactured in a plant designed and engineered by Allied's Solvay Process Division, which developed the bleaching process.

Sulfuric acid and sodium chlorate are added in series through three reaction towers. A mixture of methanol vapor and air is blown in at the bottom of each tower. As the vapor passes up through the downward stream of chemicals, a reaction occurs and chlorine dioxide is liberated. It passes from the top of the reactors into one of two absorption towers that are in parallel. There it is absorbed in water to form a solution of chlorine dioxide. A steam jet refrigeration unit cools the absorption water to 50 deg. F. The plant can turn out about 3 tons per day of chlorine dioxide.

The chlorine dioxide tower at the bleach plant in Riegel's mill is almost 52 ft. high and close to 18 ft. in diameter. Made of steel, it is lined with acid brick. Stainless steel piping and valves are lined with Saran. A Kel-F diaphragm is used. Armored ceramic pipe connects the high density pipe with the chlorine dioxide mixer.

Bleaching with chlorine dioxide constitutes a sixth stage after five normal stages of hypochlorite bleaching.

In the chlorine dioxide bleaching, stock from the second hypo washer of the fifth stage falls through a 45-ft. drop leg to a high density stock pump, which delivers it to the chlorine dioxide mixer.

Chlorine dioxide enters the mixer in a water solution. After mixing with dioxide, the stock is forced up a leg to the top of the tower. Sulfurous acid is introduced into the bottom of the tower to neutralize the corrosive effects of chlorine dioxide through pipes and the washer. From the tower, the stock goes to the washer, which is stainless steel, and then into the bleached stock chest.

Process steam at 50 lb. is supplied to the tower, and the start-up temperature in the bleach tower is 160 deg. F. Tower time for the chlorine dioxide bleaching is 240 min. Bleach liquor is not recovered from the washer.

With this sixth stage bleaching with chlorine dioxide, Riegel can get pulp with a GE brightness of 88 or better without loss in strength. This compares with a brightness averaging close to 80 after five stages of normal bleaching. The extra brightness is required for the manufacture of specialty papers at Riegel's New Jersey mills.

The new process developed by Solvay gives fine fiber with low degradation, and with long stability and high color. The added cost of sixth stage bleaching, which runs several dollars a ton, is justified by the higher brightness imparted by bleaching with chlorine dioxide.

Zirconium for chemical equipment

Big future for zirconium, according to Dr. F. S. Urban, technical director of Titanium Alloy Manufac-

(Continued on page 106)

turing Co., will be in corrosion-resistant equipment for the chemical industry. It will compete with tantalum.

Zirconium is especially effective in withstanding HCl corrosion. For a glass manufacturer, TAM recently made a zirconium nozzle for spraying HCl. But it is in the plastics industry, where it can be used in HCl heaters, and in the manufacture of phenol that Urban foresees the future large demand for zirconium.

Scramble among new polyethylene makers

Another newcomer in polyethylene production will be Monsanto. By 1955 it expects to have a plant built that can turn out 66 million pounds per year, plans a 50 percent increase in that capacity by 1957.

Interestingly, Monsanto estimates this annual capacity of 99 million pounds will represent nearly 20 percent of total U. S. polyethylene capacity in 1957 or 22 percent of the market for that year. Thus Monsanto's market researchers foresee polyethylene becoming a 450 million pound a year industry by 1957.

At its Dayton, Ohio, laboratories, Monsanto has been doing process research on high-pressure polymerization for three years. A second high-pressure pilot plant, exclusively for polyethylene, will explore alternate processes for making it, both present commercial methods and others that Monsanto has been developing for years. This may be the tipoff that Monsanto, unlike Spencer and Dow, the other two newcomers in polyethylene production, isn't going to use all of the ICI process.

Actually, Monsanto has been at work on high-pressure polymerization at Dayton for 14 years. This research has already resulted in Monsanto's vinyl chloride operations at Springfield, Mass., and Texas City, Tex., as well as other operations in Canada, Japan and Italy.

Both present producers of polyethylene are expanding. At Orange, Tex., Du Pont is increasing output of polyethylene 100 percent at a cost of more than $10 million.

Carbide & Carbon, the world's largest producer, has added at its Texas City plant a polyethylene unit that can produce 50 million pounds per year. It cost over $17 million. Carbide is building another polyethylene unit at its new Seadrift, Tex., plant.

In addition, Carbide is building the first plant on the Pacific Coast for polyethylene production. This $36 million plant will be able to turn out 50 to 60 million pounds per year. And Carbide has been granted a fast tax writeoff on a $1,406,000 polyethylene expansion at South Charlestown, W. Va.

Like Carbide and Du Pont, the two present producers, both Spencer and Dow will license the ICI process. Dow will build a plant at Freeport, Tex., and Spencer Chemical will erect one at Orange, Tex. Ethylene from the new $8 million unit at the Port Arthur refinery of Gulf Oil will be piped to Spencer's new plant and to Du Pont's expanded polyethylene plant at Orange. Spencer will borrow $10 million to finance its venture, and will produce 45 million pounds per year of polyethylene.

Texas Eastman has been awarded a fast tax writeoff for a $7 million plant at Harrison, Tex., to make polyethylene. And Semet-Solvay, breaking into ethylene polymerization, will soon be producing a waxlike polymer of low molecular weight in its new petrochemical plant at Buffalo, N. Y.

Even though polyethylene production is now about 50 times what it was in 1944, it still lags far behind demand. After World War II, use of polyethylene increased 10 to 12 times. Present demand is three times the supply, and new plants won't be ready for a year or longer.

Production of polyethylene doubled in 1952, bringing present output to almost 125 million pounds per year. Producers expect to triple current production by 1955.

Polyethylene, made by direct polymerization of ethylene at high pressure, is fast becoming the world's most important plastic in volume. Big uses are in bottles, other containers and transparent packaging, as well as electrical insulation, coatings and corrosion-resistant linings. It can also be used for molded plastic products. In its first decade, production has never kept pace with demand.

Monsanto hasn't picked a plant site yet; the final decision will depend on proximity to ethylene sources and an evaluation of the future markets for the plastic. An interesting sidelight: its entry into polyethylene will make Monsanto the first to produce all of the "Big Six" among plastics. These include styrene, phenolics, cellulosics, vinyls, aminoplasts and polyethylene.

New gage precisely measures gas pressures

Gas pressures in the range between absolute vacuum and 1 atm. can be measured accurately with a new gage developed at the Naval Ordnance Laboratory. The gage, according to the Navy, provides a new form of basic instrumentation.

It consists of two small beryllium-copper dish-shaped diaphragms that have been fastened to opposite sides of a ring to form a vacuum-tight chamber. One of the gages, only $\frac{3}{4}$ in. in diameter and $\frac{3}{8}$ in. thick, can measure a change of pressure as low as 0.01 mm. of mercury.

Silicones: they keep silicon furnace busy

Silicones are providing an ever growing market for silicon metal, an electric furnace product that is becoming more and more important to manufacturers of chemicals.

As part of its $13 million expansion in silicones, Dow Corning at Midland, Mich., has installed a big submerged arc furnace to produce high-purity silicon.

(Continued on page 110)

Where **INSUL-MASTIC** stands guard!

Moist, salty atmosphere makes the Gulf Coast of Texas the *Playground of Corrosion.* Here Refineries and Chemical Plants rely upon Insul-Mastic Coatings for protection against rust. From Brownsville to Lake Charles you will find tanks, towers, pipes, vessels and other equipment heavily sprayed with this *Superior* coating. Maintenance operations everywhere have been greatly reduced because INSUL-MASTIC's protection will last for many, many years.

Stopping moisture alone does not prevent corrosion here. Acid, alkali and other industrial vapors work hard to break down coatings and get at the metal beneath. That's why the very durable INSUL-MASTIC coatings are so extensively specified along the Gulf Coast. They are extremely resistant to chemicals as well as to moisture.

INSUL-MASTIC's record in *corrosion's playground* cannot be approached. There are many years and hundreds of jobs to prove its lasting protection. Specify INSUL-MASTIC to prevent corrosion.

Insul-Mastic's record also includes vaporsealing thermal insulation. There's no better way to keep your insulation dry.

Think First of the Coatings that Last!

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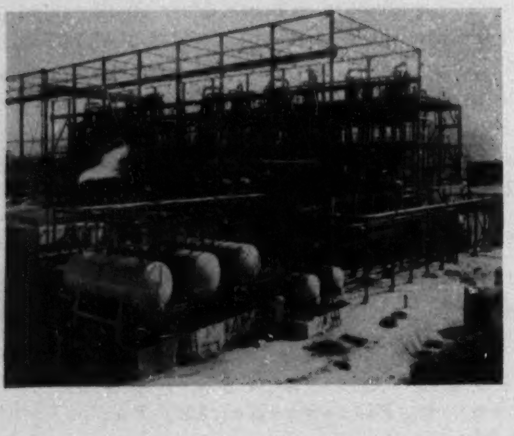
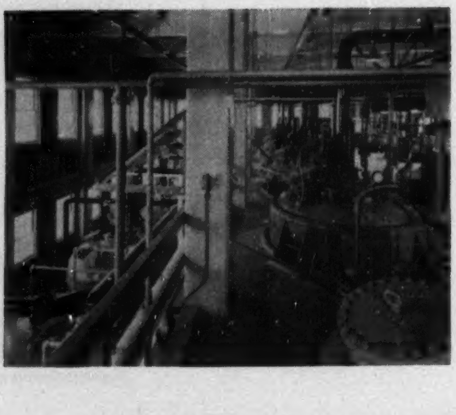




Its specially designed electrodes are of different size and uniquely spaced. At the outset, the 4,000-kw. furnace, which is just about ready to start up, will turn out about 9 tons of silicon a day. This plant to produce metallic silicon cost Dow Corning $560,000.

In other phases of its silicone expansion, Dow Corning is shelling out $10,194,000 for facilities to make basic silicone fluids and resins, $820,000 for a methyl chloride unit and $1,460,000 for a plant to produce silicone rubber. Construction of most of these units is nearing completion at Midland.

Vinyl chloride produced as Monsanto expands

Monsanto is now producing vinyl chloride monomer at Texas City. It's made from acetylene, hydrochloric acid, ethylene and chlorine.

Ethylene dichloride is produced as an intermediate in the vinyl chloride process. The Texas City plant produces enough to allow marketing of ethylene dichloride as well as vinyl chloride.

Part of the vinyl chloride produced at Texas City is going to Monsanto's plants at Springfield, Mass., and Port Plastics, Ohio, where it is converted to polyvinyl chloride and a number of copolymer resins.

Vinyl chloride reacts with vinyl acetate, vinylidene chloride and with acrylates to form a variety of industrially important copolymers.

On-stream production of vinyl chloride is the second step of the current three-way expansion of the Texas City plant. The first step was completed last July when first shipments were made from the expanded styrene monomer plant.

Nevada gets new perchlorate plant

Western Electrochemical Corp. is just starting up an ammonium perchlorate plant at Henderson, Nev., which is owned by the Navy. It will produce 50 tons per day.

Designed and built by Western, the new plant will also be operated by the company under Navy contract.

In its own plant at Henderson, Western Electrochemical now produces 6 tons per day of ammonium perchlorate. Western will soon start production of crystalline sodium perchlorate in its Henderson plant, and completing its current expansion there, will shortly be turning out manganese dioxide for batteries. The Signal Corps is sponsoring this move into production of manganese dioxide.

Monsanto steps up formaldehyde capacity

Monsanto, presently an important producer of formaldehyde in New England, will boost capacity of its Springfield, Mass., plant by 50 percent.

Makers of phenolic, melamine and urea resins in New England are increasing their demands for formaldehyde. In addition, Monsanto's own resin production has risen sharply.

The new capacity will help Monsanto to keep up with these expanding formaldehyde markets. First production from the new units is expected in 1954.

New peracetic process for hydroxylating fats

Baker Castor Oil Co. at its Bayonne, N. J., plant is now turning out synthetic hydroxylated fats. Baker uses a modification of the peracetic acid process for hydroxylation.

This modified process for hydroxylation or epoxidation by peracetic acid was developed by the Eastern Regional Research Laboratory of the U. S. Department of Agriculture.

Many chemical companies have been at work on similar processes. Among them: General Mills, with an important interest in chemical derivatives of fats; Buffalo Electro-Chemical, stimulated by a potential new market for hydrogen peroxide; and Colgate Palmolive Peet.

At least a half dozen companies are sizing up the commercial possibilities of synthetic hydroxylation. In addition to Baker, it's reported that the U. S. Department of Agriculture has also licensed Archer-Daniels-Midland and Rohm & Haas.

Baker quickly recognized the advantages of processing low-priced vegetable oils and inedible animal fat. Potential products tied in naturally with Baker's manufacturing experience and marketing pattern. Possible products of the peracetic reaction include hydroxylated and epoxylated triglycerides, esters and fatty acids.

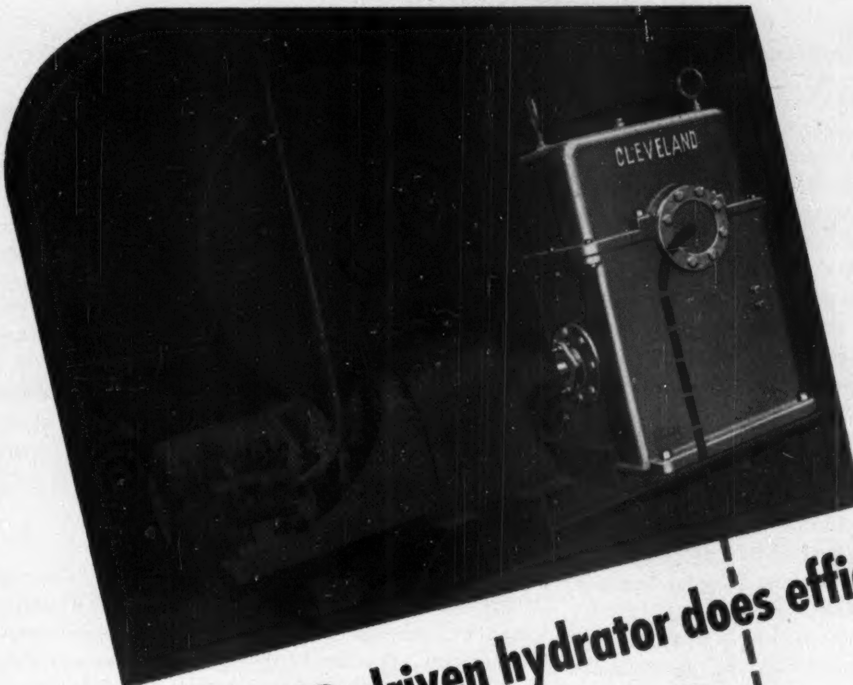
Plasticizers were picked as the prime target when Baker began work on the process in 1947. Other likely products, temporarily shelved, include lubricating oils, cutting oils, textile oils, synthetic waxes, improved drying oils, metallic soaps and cosmetic ingredients.

First two products turned out by Baker are butyl hydroxy-acetoxy ester and butyl poly-acetoxy ester. The poly-acetoxy ester is a highly efficient low-cost secondary plasticizer for vinyl resins, while the hydroxy-acetoxy ester is only slightly less so. It's believed that the butyl hydroxy-acetoxy ester may be considered a stabilizing plasticizer for vinyl resins because of its epoxy content. Both esters are primary plasticizers for cellulosic resins and synthetic rubbers. Sampling is now under way.

Baker believes these new hydroxylated plasticizers possess distinct advantages over other fatty plasticizers now in use. They have increased compatibility with vinyl chloride resins, lower volatility, greater resistance to ultraviolet exposure, stability to oxidation and freedom from rancidity. And a decisive advantage will be their considerably lower cost.

Not satisfied with its initial edge over competitors, Baker has already started semi-commercial production of a second group of derivatives, a series of synthetic

(*Continued on page 112*)



WORM GEARING—universal in its application—affords advantages for almost every power transmission job. Select worm-gear units to meet your need from the complete Cleveland line.

Photo of automatic hydrator in midwestern lime plant by courtesy of Pit and Quarry.

CLEVELAND driven hydrator does efficient mixing job

AUTOCLAVING under continuous high pressure is the crucial part of lime hydration. In this specially designed hydrator, close control of the process of mingling quicklime and water insures a product of highest quality and uniformity. The revolving agitator is driven by a Cleveland Worm Gear Speed Reducer—smoothly, at exactly the right speed, with never an interruption.

Cleveland is a compact, powerful, right-angle drive, in which a case hardened steel worm meshes with a long wearing, low friction bronze gear. Worm and gear run in an oil bath, sealed in a rugged, dust and moisture proof housing for continuous performance on the toughest jobs—in all sorts of weather—under all operating conditions.

Whenever you want a reliable, long-lived, right-angle drive, specify Cleveland. To familiarize yourself with all the types and sizes available in the complete Cleveland line, write today for Catalog 400. The Cleveland Worm & Gear Company, 3273 East 80th Street, Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.

CLEVELAND

Speed Reducers

hydroxystearic acids. Dihydroxystearic and polyhydroxystearic acids are being offered.

Markets for these new hydroxy acids are expected to develop in grease manufacture, cosmetics, metallic soaps and cutting oils. They are currently undergoing test by users.

For organic synthesis, the synthetic hydroxystearic acids and the butyl hydroxy-acetoxy ester provide unique starting points. Possible reactions of these multi-hydroxy products are sulfation, acylation, amination, oxidation, isocyanate coupling, condensation with urea and esterification with phosphoric acid.

Anhydrous HCl at low cost for new vinyl plant

General Tire & Rubber Co. has finally decided to go ahead with its polyvinyl chloride resin plant. It will cost about $6 million. To finance the new plant and other phases of its current expansion, General Tire will sell its stock in Mansfield Tire & Rubber Co.

The vinyl plant will be located on a 50-acre site at Ashtabula, Ohio, not at Calvert City, Ky., as originally contemplated. Acetylene will come from Linde's plant at Ashtabula, now serving Hooker. Anhydrous HCl will come from Hooker-Detrex via pipeline.

Hooker-Detrex will get the anhydrous HCl as a byproduct of trichlorethylene production at Ashtabula. The Hooker-Detrex plant is now being revamped to use a new trichlorethylene process, the result of six years of work carried out by Detrex with the cooperation of Hooker Electrochemical.

Its new trichlorethylene process makes it possible for Hooker-Detrex to offer anhydrous HCl to General Tire at a lower price than General would have to pay at Calvert City. This, plus the advantages of the Ashtabula location, will mean a yearly saving of $350,000 over Calvert City.

Capital costs for General Tire will be $500,000 less because pipelines can be shorter at Ashtabula and a water system is already on the site.

By locating at Ashtabula, one source estimates, General Tire can save $150,000 to $200,000 a year on shipments of outbound product alone. General's finishing mill for vinyl plastics is at Jeannette, Pa.

Hooker-Detrex will have its new trichlorethylene process in operation by April 1954. When General's new $6 million vinyl plant at Ashtabula is ready to run, Hooker-Detrex will pipe its byproduct anhydrous HCl to the vinyl unit. Scientific Design of New York is designing General Tire's vinyl resin plant.

More manganese dioxide for batteries

Electrolytic manganese dioxide is now being produced commercially at the Portland, Ore., plant of American Metallic Chemicals Corp.

Manganese dioxide is used in the manufacture of other chemicals, as a drier in paints and varnishes, in ceramics and in metallurgy. Its biggest use, however, is in the production of dry cell batteries.

When electrolytic manganese dioxide is used instead of the African ore, the life of a battery is reportedly increased. In addition, electrolytic manganese dioxide reduces weight.

American Metallic Chemicals will produce manganese dioxide by electrolytic oxidation of a manganese solution. The process entails grinding, roasting, washing, leaching, purification and electrolysis. AMC researchers have come up with new techniques for increasing plant efficiency.

AMC also plans electrolytic production of sodium perborate, both tetrahydrate and monohydrate, at its Portland plant. It's expected that production will start early in 1954.

Zirconium by arc dissociation

Zirconium is produced by the arc dissociation of halides in a new process developed by National Research Corp. of Cambridge, Mass., for the U. S. Atomic Energy Commission. It is one of the few continuous methods for zirconium reduction from which the AEC has lifted the security curtain.

The process may be commercially interesting for production of special grades of titanium and zirconium.

However, as National Research experts point out, the new method should not be considered a satisfactory answer to the major problem of finding a cheap method for tonnage production of titanium and zirconium. In partnership with Monsanto, National Research is currently engaged in a quest for such a cheap process.

Refractory oxide from byproduct chloride

The process that International Minerals & Chemical Corp. will use in a new plant at its Carlsbad, N. M., refinery provides an economical way to convert an impure magnesium chloride byproduct into high-quality magnesium oxide for the manufacture of heat-resistant brick. Simultaneously, hydrochloric acid is produced.

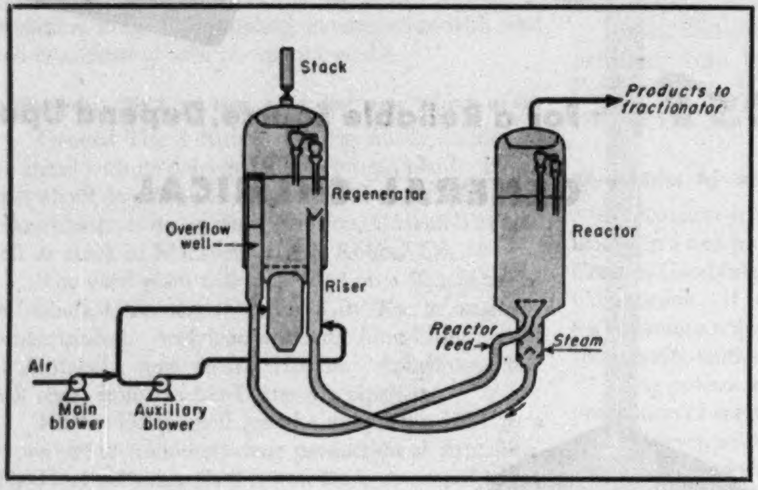
Starting material is byproduct magnesium chloride. It comes from the ion exchange process used to get potassium sulfate from potash ore.

Magnesium chloride is processed in rotary kilns. In the new process, which Allis-Chalmers helped International to develop, the magnesium chloride is ground, dewatered, filtered and heat-treated to produce a high-purity magnesium oxide lower in calcium, iron and silica than most commercial magnesia. Hydrochloric acid is the other product.

International Minerals will make a variety of periclase products, including magnesia for electrical elements and other refractories. The hydrochloric acid will be marketed in the Southwest, where it will be used for acidizing oil wells. International expects to start up its new plant at Carlsbad next month.

(What's Happening, turn to page 114)

What's Happening



FEATURE NEWS

Latest Fluid Cat Cracker

Model IV's completely new catalyst circulation system does away with throttling slide valves. Easier process control and more stable operations result.

Continuing the trend toward simplified design in catalytic crackers, Standard Oil Development Co. has come out with a new fluid cat unit, Model IV. Major difference between Model IV and its predecessors lies in the new catalyst circulation system which eliminates slide valves for controlling the rate of catalyst transfer between vessels. This means major savings in maintenance.

And big reductions in over-all height have been effected, too. New units less than 100 ft. high have the same capacity as older units standing 140 ft. or higher. The more than 30 percent saving in steel realized by these lowered heights greatly reduces initial construction costs.

First commercial installation went on stream in December at the Edmonton, Alta., refinery of Imperial Oil, Ltd. Designed to process 11,000 barrels per day of gas oil–including 2,490 bpd. recycle–it is the first of more than 20 units now being designed or built.

▶**How It Works**–Gas-oil feed stock mixes with hot regenerated catalyst just below the reactor and is instantly vaporized (see cut). A two-stage cyclone in the reactor separates catalyst from the reaction products and spent catalyst is steam-stripped of oil in the lower section of the reactor.

Spent catalyst density is lowered by injecting air into the riser just ahead of the regenerator. This allows the catalyst to flow under its own pressure-head. Thus the air flow-rate controls the spent catalyst rate and also the catalyst-to-oil ratio, making throttling slide valves unnecessary.

This simple catalyst transfer system has also erased another headache—"reverse flow" (spent catalyst getting into the reactor or regenerated catalyst and oil getting back into the regenerator).

Any serious pressure difference between the two vessels—common cause of reverse flow—will cause the catalyst to defluidize into a dense phase forming a temporary seal. As soon as pressures are back in balance, the catalyst refluidizes itself and normal circulation is restored. Esso engineers claim that this principle makes Model IV safer, more stable and easier to operate than any previous fluid catalytic crackers.

▶**Operating Data**–The Edmonton unit, constructed by Foster Wheeler, Ltd., is designed to produce 96-octane gasoline (research method, unleaded) at 60 percent gas-oil conversion. Reactor bed temperatures are near 900 deg. F. at 12.8 psig. Catalyst circulation rates of 225 tons per hr. with a catalyst-to-oil ratio of 10.9 are normally used.

The regenerator is designed to burn 8,500 lb. of coke per hr. at 1,125 deg. F. and 16.5 psig. It is equipped with a two-stage cyclone to separate flue gases from the catalyst.

The process is available to industry under license from Standard Oil Development Co.

in Chemical Engineering

Fork Truck-Trailer Team-Up . . .

Payroll savings will take only 48 weeks to pay for new plant haulage system that ups labor efficiency and cuts equipment maintenance charges.

Common method of transferring palletized loads of containers, raw materials, finished products from department to department in chemical plants is to use flat-bed trucks.

Bill Gaskie, superintendent of the Yard and Shipping Dept. at the Warners Plant of American Cyanamid (Linden, N. J.), saw a double-barreled improvement over this method: (1) substitution of trailer trains for flatbed trucks and (2) the novel idea of using fork trucks instead of tractors for pulling the trailer trains.

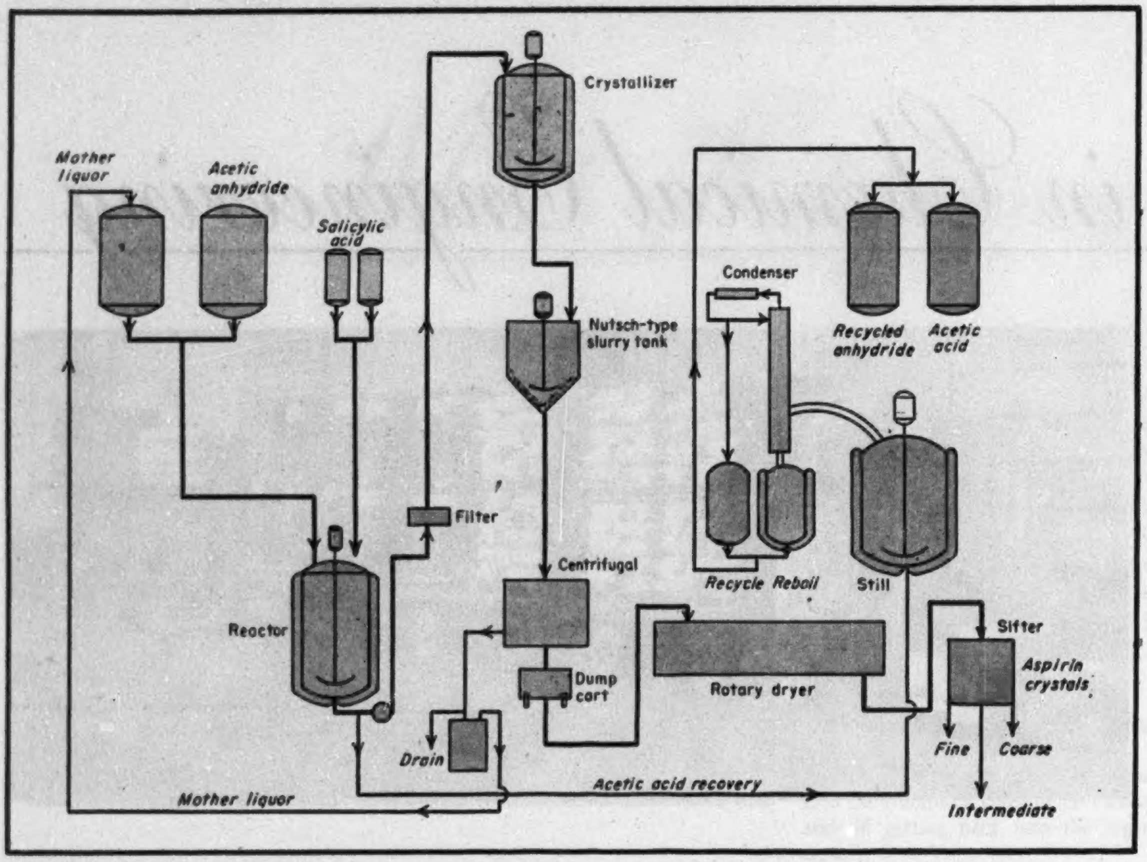
This second feature permits the operator to detach his fork truck from the train, transfer palletized loads, hook-on to the train and continue to the next unloading station—all without getting out of his cab. Separate trucks for hauling and lifting are not required in this scheme.

The table summarizes the benefits of the new system; savings in labor charges, reduced maintenance, substantial improvement in hauling labor efficiency both from the standpoint of weight and space occupied. Space occupied becomes important with empty containers.

To these improvements can be added savings in loading and unloading time, since most departments did not have mechanical equipment available before the change to the new hauling system.

. . . Saves Over $18,750

	OLD SYSTEM	NEW SYSTEM
LABOR—Costs reduced by $18,750 per year		
Men	7	4
Overtime	Yes	No
EQUIPMENT—Maintenance costs are negligible for trailers		
Flatbed trucks	3	1
Lift trucks.	1	2
Trailer trains	0	2
HAULING CAPACITY—Increased by 108 percent		
Tons, total	9.6	20
Tons per man.	1.37	5.0
HAULING SPACE—Improved by 59 percent		
Sq. ft., total.	288	456
Sq. ft. per man.	41.1	114



REACTION SCHEME, a penthouse arrangement, utilizes gravity flow, moves materials with a vacuum-and-pressure egg.

Taking Headaches Out of Aspirin Production

Norwich Pharmacal's new plant licks three traditional problems: high purity, good yields and low cost.

The country's newest aspirin plant, the $150,000 unit of Norwich Pharmacal Co. at Norwich, N. Y., is one of the most up-to-date processes anywhere for turning out crystals of the well-known headache reliever.

Aspirin, one of the first antipyretic analgesics, is chemically acetyl-salicylic acid. It's made by the acetylation of salicylic acid with acetic anhydride. Norwich uses direct combination of acid and anhydride in a medium of mother liquor from the preceeding reaction cycle.

▶ **Production Up**—With production of more than a million pounds of crystal slated for 1953, the company is getting a hefty foot into the door of synthetic medicinals. (Last year, Chem. Eng., Sept., p. 236, Norwich announced production of nitrofurans, new furfural derivatives with antibiotic activity.)

Jim Shuessler, chemical superintendent at Norwich and one of the key men behind the company's chemical expansion, points out that aspirin crystal is the one pharmaceutical that approaches heavy chemical volume. Consumption is on the increase, too; in 1950 we consumed about 11 million pounds; in 1952, 12 million—and that's a lot of headaches.

The secret of the process is very careful control of the time-temperature cycle.

▶ **How It Works**—Reaction takes place in a 500-gal. glass-lined Pfaudler reactor to which the proper equivalents of salicylic acid powder, acetic anhydride and mother liquor have been added. Norwich won't give exact details but reaction takes 2 to 3 hr., gets up to 90 deg. C. At the end of the reaction period, the liquid mass is pumped through a stainless steel filter to take out any extraneous matter that may have been in the raw materials.

Next, the reaction mass is pumped to a crystallizing kettle (another 500-gal. glass lined reactor). Because crystallization takes 16 hr., three kettles serve one reactor.

The reaction liquid is at 70 deg. C. when it enters the crystallizers; first cold well water, and then refrigerated water get it down to 3 deg. C. At least 50 percent of the crystals are close to 20-mesh, the best size for tableting.

▶ **Finishing Steps**—When crystallization is complete, the material is dropped into a modified nutsch-type slurry tank. Here a portion of the mother liquor is drawn off to be used in the next aspirin batch. The remaining slurry is

New Plastic Bodies Make Possible Sports Cars for the Average Family

The drawing-board dream of a compact, sports-type family car . . . easy to handle in traffic, economical to buy, operate and maintain . . . may soon come true.

For polyester resin reinforced with glass fiber now permits the construction of *one piece* auto bodies, which greatly reduce sports car assembly costs. The light weight and great strength of such bodies also cut sports car operating and maintenance costs.

RCI, the world's leading producer of synthetic resins, furnishes polyester resins to many industries. RCI makes its polyester resins with full quality control, since it supplies itself with their basic raw materials, phthalic anhydride and maleic anhydride.

Reichhold also manufactures phenol, formaldehyde, glycerine, sodium sulfate and sodium sulfite.

REICHHOLD CHEMICALS, INC.
630 Fifth Avenue, New York 20, N. Y.

Uses of RCI Products

CANVAS, PAPER AND GLASS CLOTH LAMINATES: PLYOPHEN cresol, phenolic and resorcinol-formaldehyde resins and varnishes; POLYLITE polyester resins.

CARBON PAPER: RCI inorganic chemical pigment colors.

CASTINGS: FOUNDREZ powdered phenolic resins (for the shell molding process); FOUNDREZ liquid phenolic resins and FOUNDREZ core oils (for core binders).

FURNITURE, PLYWOOD, FLOORING, HARDBOARD AND CHIPBOARD: HYDROPHEN phenolic glues; PLYACIEN protein glues; PLYAMINE urea-formaldehyde glues; PLYOPHEN phenolic and resorcinol-formaldehyde glues.

LEATHER: BECKOSOL alkyd resins (for leather finishes); PLYOPHEN resorcinol-formaldehyde resins, SUPER-BECKACITE pure phenolic resins, SYNTHE-COPAL ester gums (for leather adhesives).

LINOLEUM: BECKOSOL alkyd resins and PENTACITE pentaerythritol resins (for linoleum coatings); RCI inorganic chemical pigment colors.

PAINTS, VARNISHES AND LACQUERS: BECKACITE (1) fumaric, (2) maleic and (3) modified phenolic resins; BECKAMINE urea-formaldehyde resins; BECKOLIN synthetic oils; BECKOPOL modified phenolic resins; BECKOSOL (1) phenolated, (2) phthalic-free, (3) rosin modified, (4) pure drying and (5) pure non-drying alkyd resins; KOPOL processed Congo copals; PENTACITE pentaerythritol resins; STYRESOL styrenated alkyd resins; SUPER-BECKACITE pure phenolic resins; SYNTHE-COPAL ester gums; WALLKYD pure drying alkyd resins (for alkyd flat wall vehicles); WALLPOL vinyl-type copolymer latex emulsion (for latex flat wall coatings); RCI inorganic chemical pigment colors.

PAPER: BECKAMINE urea-formaldehyde resins (for adding wet strength, improving the wet rub of starch-clay coatings, and waterproofing starch adhesives); RCI inorganic chemical pigment colors (for paper coloring); STYRESOL styrenated alkyd resins (for paper coating).

PRINTING INKS: BECKACITE fumaric, maleic and modified phenolic resins; BECKOLIN synthetic oils; BECKOPOL modified phenolic resins; RCI inorganic chemical pigment colors.

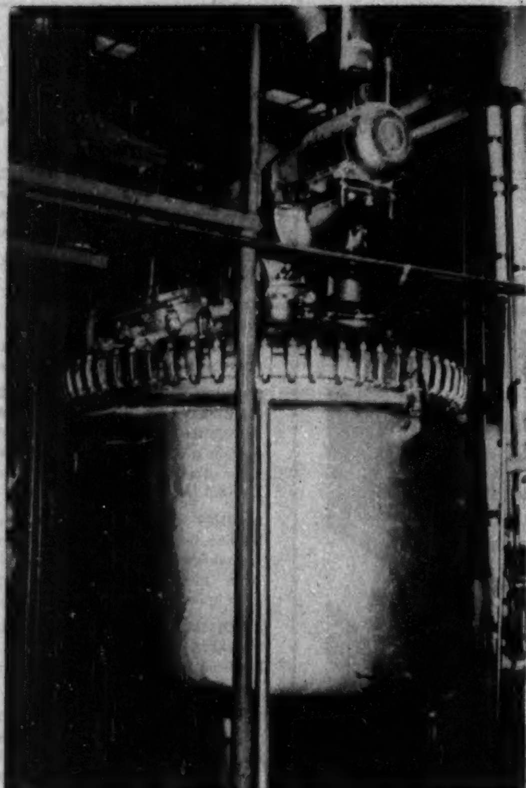
TYPEWRITER RIBBONS: RCI inorganic chemical pigment colors.

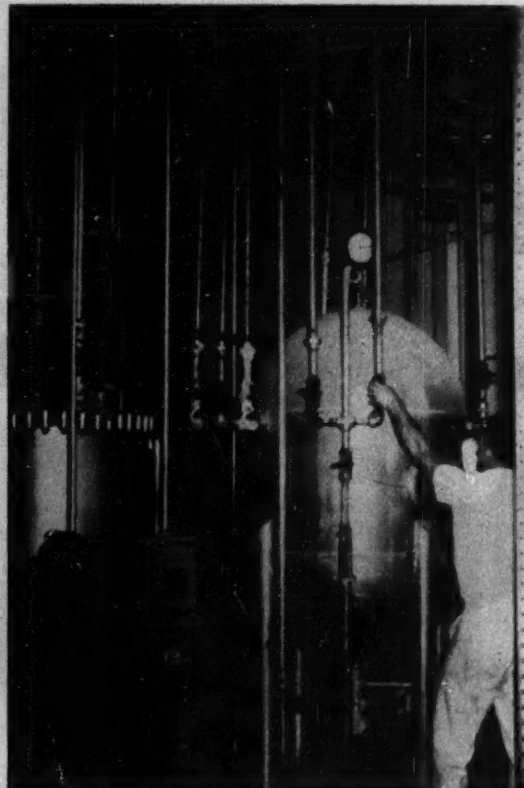
WAXES AND POLISHES: BECKACITE modified maleic resins; SUPER-BECKACITE pure phenolic resins; SYNTHE-COPAL ester gums.

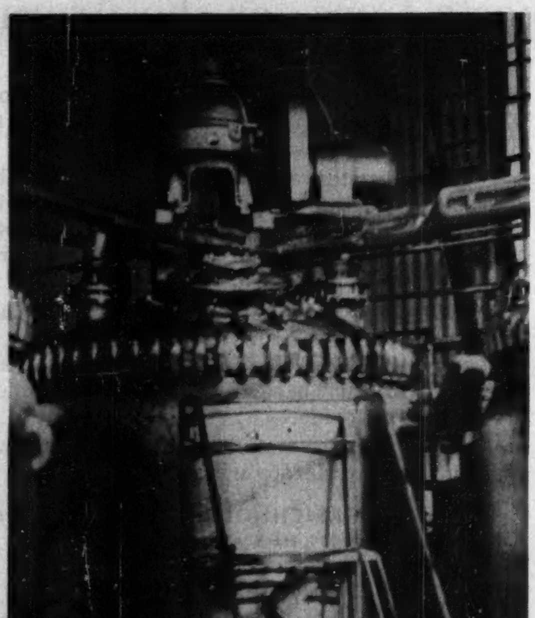
Creative Chemistry . . . Your Partner in Progress

REICHHOLD

RCI







Key Steps . . .

1 Reaction combines salicylic acid with acetic anhydride.

2 Vacuum-and-pressure egg moves material to one of the plant's three large crystallizers.

3 Crystallization takes about 16 hr. in 500-gal. glass-lined equipment cooled down to 3 deg. C.

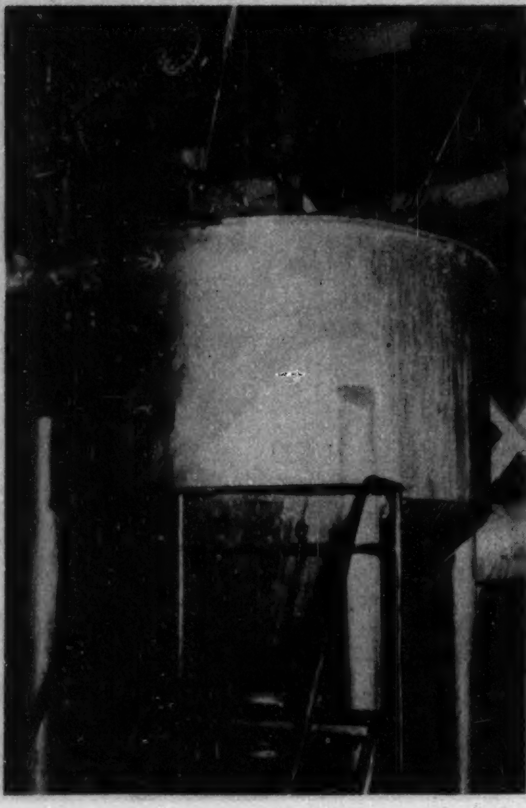
ASPIRIN, cont. . .

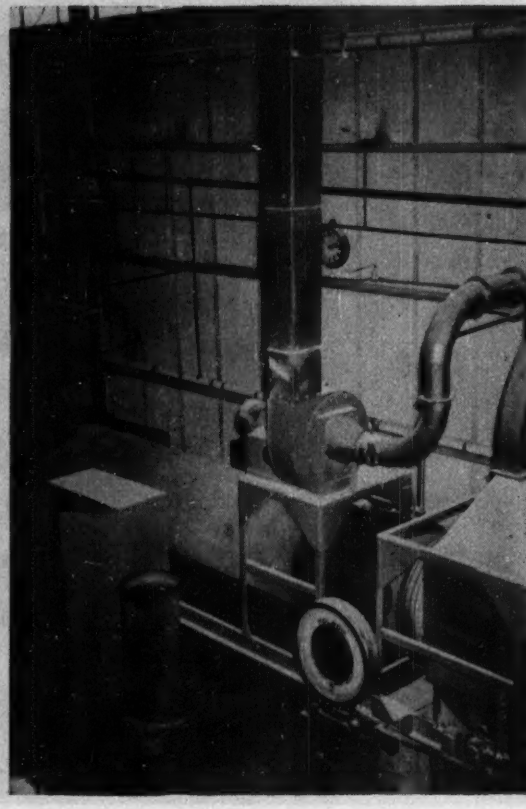
dropped down into a centrifugal where it is spun free of mother liquor and washed. The batch is then plowed from the centrifugal and placed in a dump cart which is used to feed a rotary dryer. A flow of warm, dry air parallel to the flow of aspirin takes out the moisture. The finished, dried aspirin is then diverted to the finishing operations of sifting, granulation and tableting.

The mother liquor in excess of that used for the following batch is stored in an aluminum tank; after about 15 normal reactions enough mother liquor has collected for distillation to acetic acid. Concentrated solids from the still bottoms are further processed to produce usable grades of aspirin.

Purity of aspirin from the still bottoms is watched


BROWN & ROOT



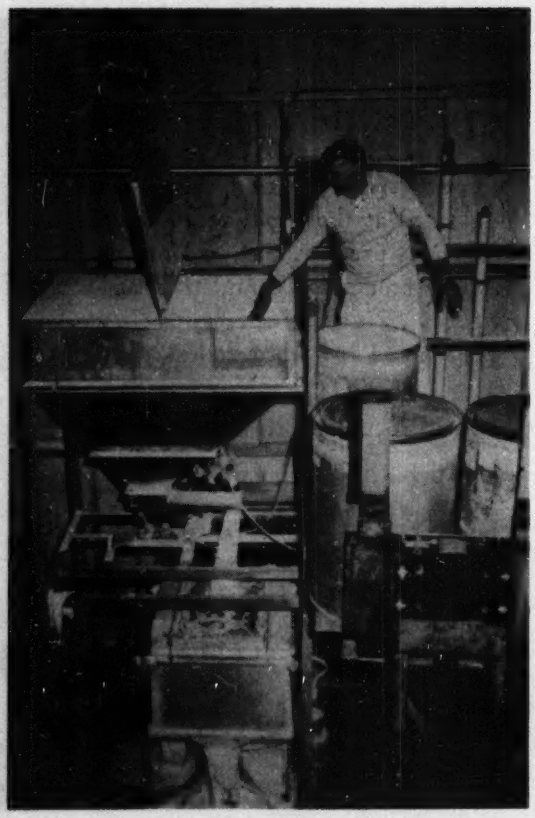


Key Steps . . .

4 Modified nutsch-type slurry tank receives crystalline slurry.

5 After centrifuging, a rotary dryer removes remaining moisture from the crystalline product.

6 Lastly, a sifter separates fine medium and coarse crystals for tableting or bulk packaging.



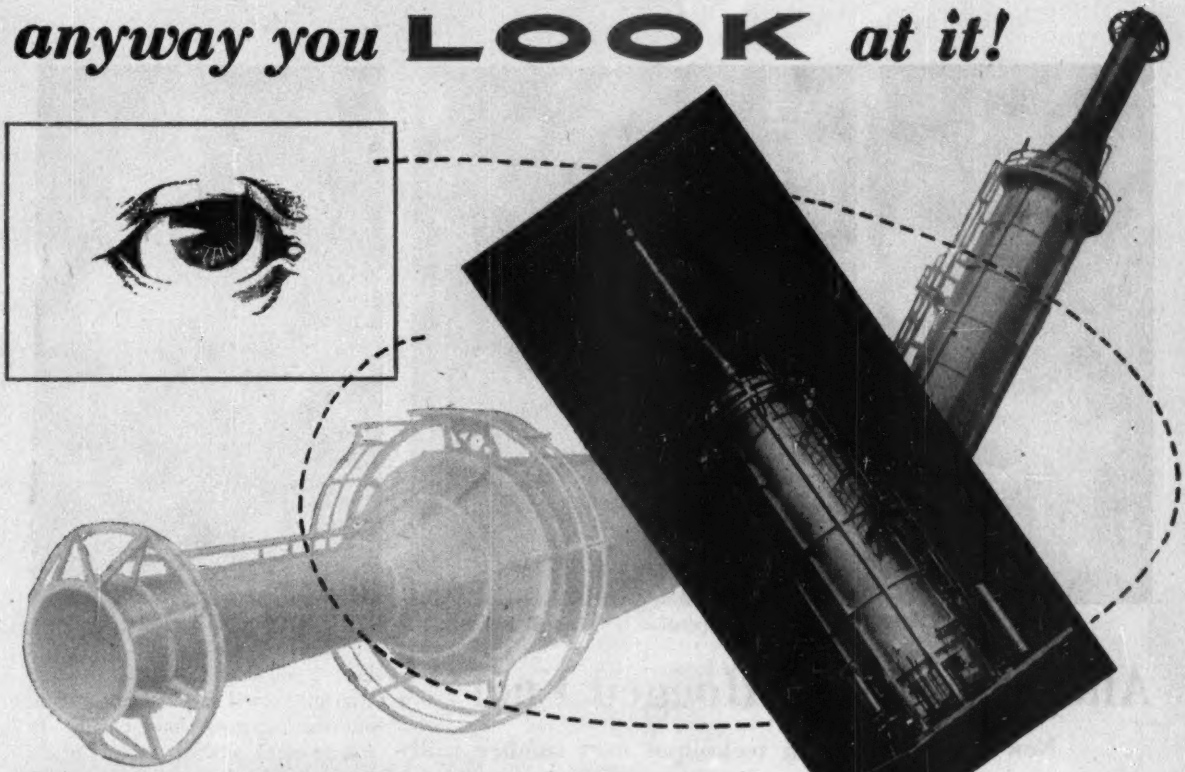
ASPIRIN, cont. . .

very closely. If the material fails to meet standard it is discarded.

"Because of the highly competitive nature of this process, I can't tell you how much is discarded, or what our yields are" says Shuessler, "but with the close cost-profit picture in aspirin manufacture, yields are good and waste is very small." (Because of the close profit margin, yields of a commercial process are usually 90% or better.)

The entire processing operation is instrument-controlled to the point where two men per shift can handle all operations. An electric lift truck is used to handle dry solids and a vacuum-and-pressure egg is used to move liquid ingredients.

anyway you LOOK *at it!*



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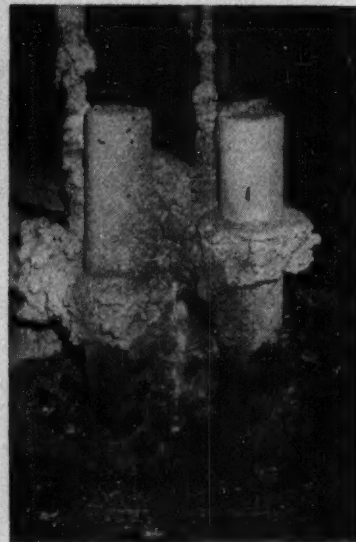
COMPARE cleanliness of operation with hogged fuel vs. . . .



REDUCTION with charcoal.

Alloy Pigs From Hogged Fuel

New electric smelting technique uses lumber mill wastes to control temperature, produces metals from "unsmeltable" ores easily and cheaply.

Recent work by the Bureau of Mines may point the way to improved operation in the production of ferroalloys and other electrothermal products.

This development is the substitution of wood waste for a good part of the coal, coke or charcoal normally used in the furnace charge as the reducing agent. In this way it is possible to control smelting temperatures by regulating charge densities. Other carbonaceous materials such as corn cobs, nut shells, fruit pits, peat and lignite can also be used, and the principle is said to be applicable to every electric smelting operation.

A patent on the process has been applied for by Robert T. C. Rasmussen, formerly with the bureau. It will be assigned to the government.

Use of wood waste in electric smelting is, in itself, not new. Ferrosilicon producers have practiced adding minor amounts to their furnaces to get a more porous charge so that gases generated in smelting can escape freely. Rasmussen observed, however, that the use of larger proportions of wood waste not only gives a more porous charge, but also helps control the feed rate to the smelting zone and the smelting temperature.

▶ **How It Began**—This idea grew out of work done on silicon alloys by the bureau's Albany, Ore., station. Earlier work on a silicon-aluminum alloy using a single-phase bottom-electrode furnace did not prove commercially attractive. In October 1951, therefore, the bureau began work on improving the process in a three-phase top-electrode furnace.

All of the bureau's first seven runs failed—the furnace kept filling up with frozen slag from melted, but unreduced, ore. In December, prior to starting the eighth, and last, run, Rasmussen decided that if slag appeared once more, he would stop charging to the furnace any material that would add to slag.

Within 24 hours it happened, so for 36 hours thereafter the furnace was charged with nothing but sawdust. As a result, the furnace became overcharged with carbon, and carbides formed at the electrodes—but the slag problem was licked.

▶ **Explanation**—Formation of slag when carbon is added in the form of coke or charcoal is attributed to the fact that pyrophyllite, the aluminum silicate ore, melts at about 1,700 deg. C., while its reduction temperature is about 2,000 deg. C. Ore descending at an unchecked rate did not stay in the smelting zone long enough to heat up much above its melting point; part of it passed on to the hearth in an unreduced state.

Wood waste or sawdust (known in the lumbering industry as hogged fuel) actually dilutes the ore in the charge, multiplying equivalent charge volume 6 to 7 times. Accordingly, the rate at which a given weight of ore descends in the furnace is retarded, and a greater portion of the power input can be used to raise the smelting zone temperature above the melting point of the ore.

Hogged fuel also provides a porous, dry, top cover of unfused charge that permits escape of gases, condenses rising metal vapors and provides excellent insulation. Other claims are:

- Furnace operation becomes more uniform.
- Correct smelting zone temperatures for optimum reduction and minimum power and electrode consumption are attained.
- Loss of metal vapor through blowing is reduced.
- Carbon costs are lowered. Based on $1-per-ton hogged fuel, metallurgical coke would have to sell for no more than $8 per ton to compete on a carbon-equivalent basis.
- Ores that would normally require sintering or other agglomeration treatment before smelting can be smelted directly.
- The process is applicable without

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PEBBLE AND BALL MILLS
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modification to both slag-forming and non-slag-forming operations.

▶ **Commercial Prospects**—In addition to its work on silicon alloys, the bureau has worked out a smelting process applicable to the production of ferronickel. This process, involving selective reduction, incorporates the use of hogged fuel. M. A. Hanna is reported to be building one of the world's largest smelters at Riddle, Ore., to use this method. The smelter will cost some $25 million.

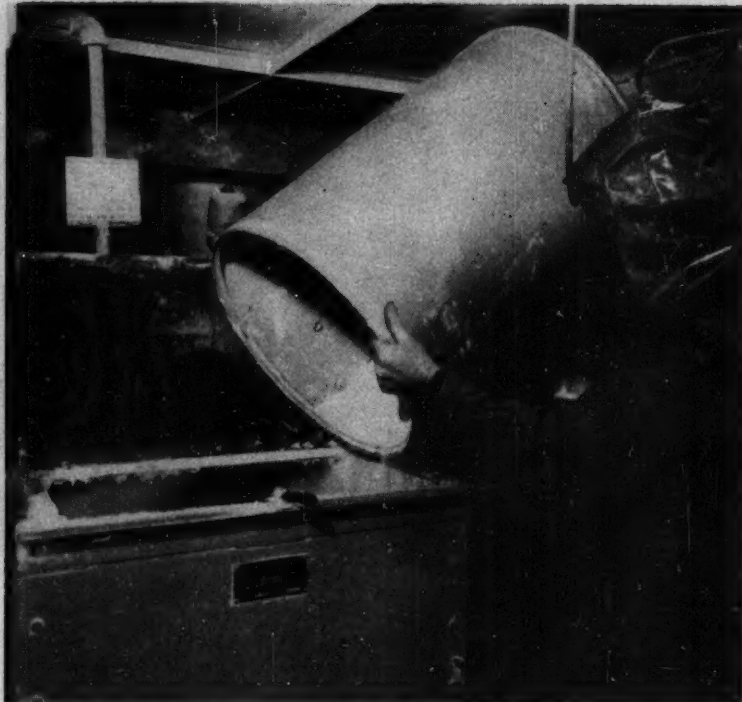
While working on ferronickel production, the Bureau found that too much hogged fuel increases smelting zone temperature too much, adversely affecting power and refractory consumption. This is also true in production of silicon metal, where silicon carbide is formed. The optimum amount of hogged fuel will have to be determined empirically in each smelting application.

▶ **More To Come**—There are three other applications of the Rasmussen process that should find commercial realization soon: Smelting of silicomanganese, chromite, and Scappoose (Ore.) iron ore.

The bureau has produced silicomanganese by the new method from low-grade rhodonite containing 26.5 percent Mn and 45 percent SiO_2. It has already been tested in steel production, where it satisfactorily replaced ferromanganese and ferrosilicon. Used thus, 20 percent or more of the steel industry's manganese requirements could be met with low-grade domestic ore.

The government has contracted to buy 900,000 tons of 38-percent Cr_2O_3 Montana chromite over the next eight years. Up to now the low chrome/iron ratio and finely divided state of the concentrate has prevented its widespread use. The low ratio, however, no longer is considered a problem, and the Rasmussen process can handle the finely divided concentrate as is.

Scappoose ore has a high water content and a small particle size that normally would require nodulizing or sintering before smelting. As a result, it is currently used only in pigments and gas scrubbing. But since the Rasmussen method can handle unnodulized ore, saving $6 to $9 per ton in charge costs, some attention is being given to the possibility of smelting Scappoose ore to produce iron for use in foundry work.



NEW SYSTEM for handling dusty plastic ingredients is aimed at . . .

Turning Out Vinyls Sans Dust

Keeps the handling of toxic dusts restricted to a well-ventilated enclosure. All other dusty materials are changed to pastes or sealed in soluble plastic bags.

The use of powdered lead compounds as stabilizers in the manufacture of vinyl plastics has long been a health problem to workers in these plants.

But now Alex E. Goss, senior industrial hygiene chemist with the Connecticut health department, and Arthur M. Ross, Jr., of Ross and Roberts Co. in Stratford, Conn., have worked out an effective method to control lead dust in the Stratford plant.

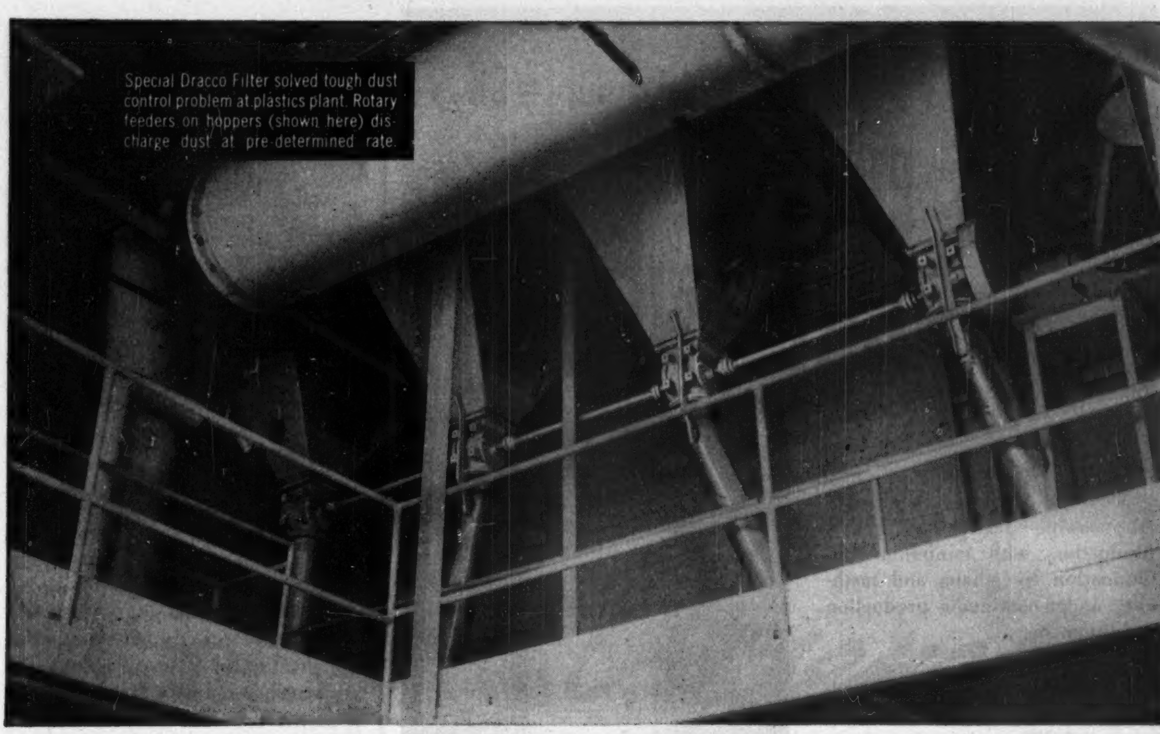
Briefly, with the new method these lead compounds, as well as other powdered stabilizers, colors or pigments, are: (1) Transferred from their original containers in an exhausted enclosure; and (2) either processed into non-dusty forms; or (3) weighed into plastic bags and sealed before entering the factory proper.

Here are the details:

1. All transfer of dusty materials out of their original containers is restricted to a single exhausted enclosure equipped with the necessary handling equipment, scales, air supply for the respirators and other essentials. The old method called for all the ingredients of the polyvinyl chloride composition to be weighed out into open metal containers. Similarly, transfer of these powdered materials from blender to Banbury to mill to calender evolved considerable dust with each transfer until the point at which the materials left the mill.

Broken and empty bags allowed even more dust to collect in the atmosphere. Even with strong ventilation, a worker was compelled to wear a respirator for a full working day for adequate protection—a discomfort the average worker could hardly be expected to put up with.

2. Whenever possible, dusty materials are processed into non-dusty pastes by mixing with plasticizers and subsequent grinding. Batches are made as large as practicable to mini-



Special Dracco Filter solved tough dust control problem at plastics plant. Rotary feeders on hoppers (shown here) discharge dust at pre-determined rate.

HOW DO YOU CONTROL COMBUSTIBLE CORROSIVE DUST?

●The Rohm and Haas Company, manufacturers of chemicals, plastics and resins, solved a serious problem of this type at its Bristol (Pennsylvania) plant by relying on Dracco techniques and equipment.

Dracco dust control engineers were called in to work with Rohm and Haas project engineers on the problem. This cooperative team supplied the "Performance Proved" answer for capturing combustible, corrosive acrylic resin dusts.

Dracco equipment specified for this application was a custom-designed Multi-Bag Filter with corrosion-resistant all-aluminum construction. Special features incorporated for protection against fires or explosions were: rupture plates with explosion vents leading to plant exterior, explosion-proof motors, static-proof V-belts and grounding strips woven into the cloth filter bags.

This dependable Dracco system operates continuously, recovering virtually 100% of the 325-mesh dust for re-use in the process. Both plant safety and operating efficiency have been improved as a direct result of this installation.

If your dust problem involves new or unusual materials, rely on Dracco engineers for the best in dust control.

DRACCO CORPORATION
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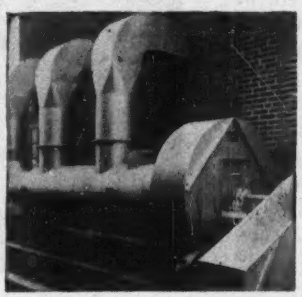
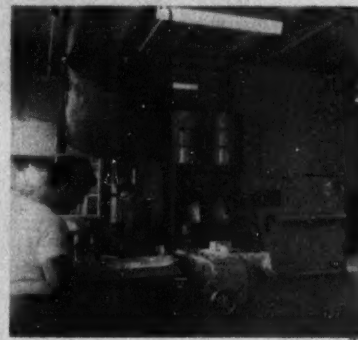


Exhaust manifold and Dracco fan assembly for Rohm and Haas installation.

DRACCO *Performance Proved*

Airstream CONVEYORS • DUST CONTROL EQUIPMENT



PIGMENTS are first slurried in a pony mixer, then ground to paste.

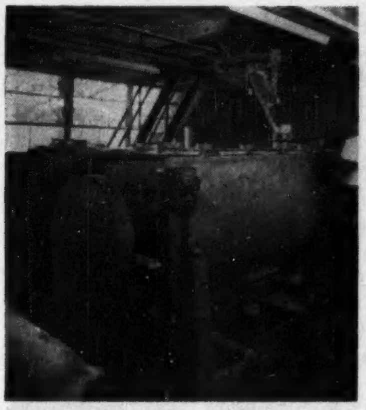
mize the number of weighings of powdered material.

3. When it's not possible to put the dusty material into paste form, it's weighed into plastic bags which are hermetically sealed before they're brought into the factory.

The exhausted enclosure consists of three sections. The first is used mostly for the weighing of bulk colors into pony mixer cans in large batches; the second section, where lead stabilizer is added, contains a ribbon-blade mixer large enough to hold a full drum of stabilizer, (eliminating any reweighing); the third section handles the addition of white pigments.

The entire enclosure has a slot exhaust of 3.5 in. at the floor running its width; it's exhausted to an exterior dust collector at a high rate of exchange. In the first section the equipment is arranged so that the air flow comes over the workman's shoulder and down toward the floor to move the dust away from his breathing zone. If the dust is toxic or objectionable, the weigher wears an air-supplied helmet. The pony mixer is equipped with a semicircular exhaust hood so that any dust raised during mixing is carried off to the dust collector.

Slurry produced in the pony mixer is then transferred to a three-roll paint mill, ground to the desired fineness, standardized and transferred to storage containers. These pastes are stable enough to permit indefinite storage without settling. They are delivered, accurately and neatly into plastic bags set on the pan of the weigh scale, by means of an air-driven reciprocating pump with hose and hand nozzle. The plastic bag is then sealed and delivered to the Banbury mixer floor. Color pastes too concentrated for convenient



BLENDERS with ribbon blades mix the vinyl resins with the plasticizer.

weighing may be diluted with resin in a planetary mixer and subsequently weighed into plastic bags in the conventional manner.

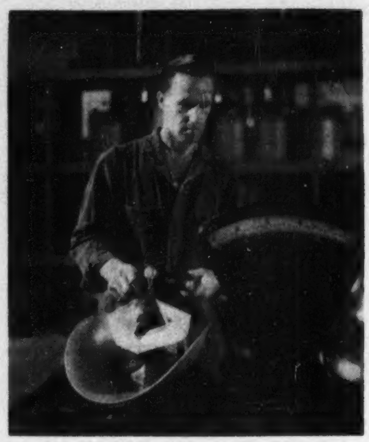
A unique feature of the system is the fact that the sealed plastic bags (containing the color pastes, lead stabilizer pastes and white pigments) are dropped, as such, into the Banbury. The bags do not burst until they have fallen into the Banbury cavity, and eventually the bag simply dissolves in the mix.

In the second section of the enclosure, where the stabilizer is added, ventilation is at a very high rate. After the ribbon-blade mixer has been loaded with stabilizer, the calculated quantity of plasticizer is metered into the closed mixer and the two are combined. The contents are then pumped into one of the two reservoirs located above a pair of colloid mills which deliver a smooth, stable and non-settling paste into portable drums. From the drum this paste is pumped to a plastic bag on the weigh scale in the same manner as the color pastes. This operation eliminates any necessity for dry screening of the lead stabilizer with its attendant dust clouds.

The third section of the enclosure has two decks, the upper of which is used for storing bags of white pigments which may be used in quantities too large to permit grinding into pastes. Into this upper deck project the mouths of two storage hoppers. During the loading of bags of powdered materials into these hoppers, this upper deck is exhausted to the dust collector and the workman wears an air-supplied respirator.

At the lower level, a traveling scale receives the pigment from one of the hoppers into a plastic bag mounted

BANBURY receives the vinyl slurry. Bag holds stabilizer, fillers, pigments.



PASTE pumped through hose, weighed into bags.

in a special holder on the scale pan. Flow of material from the hopper is regulated by a foot pedal which starts and stops the vibratory feeder to permit precise weighing without excessive dust being evolved. These bags are sealed within the enclosure before delivery to the Banbury floor.

To assess the degree of control obtained at the plant, Ross and Goss have made exhaustive physiological tests—including inhalation and urinary analyses. They found that under the new system, wearing of the respirator was necessary for only 20-30 min. each day instead of an entire day. Total inhalation of lead dust by any worker was well below the permissible level of 0.15 milligrams of lead per cubic meter of air per 8-hr. work period.

The highest average urinary lead concentration recorded in the plant

was 0.08 milligrams per liter. The allowable concentration, here too, should be kept below 0.15 milligrams of lead per liter.

Rohm & Haas Now Making Dimethyl Formamide

Dimethyl formamide is now being produced commercially by Rohm & Haas Co., Philadelphia, in drum and tank-car quantities.

This solvent will dissolve synthetic and natural resins, inorganic salts and gases, and other chemicals.

In particular, it is important for the purification of acetylene, as a solvent medium for organic reactions, as a solvent for acrylonitrile polymers and for highly selective solvent extraction processes.

Rohm & Haas is developing outlets for its dimethyl formamide in the chemical process industries and in the textile and paint industries.

Simplot Becomes Idaho's First Triple Super Maker

First triple superphosphate fertilizer produced in Idaho is now coming from new installations at the Pocatello, Idaho, plant of J. R. Simplot Co.

The second of three Oliver horizontal filters has been installed. When the third is in place this fall, Simplot expects annual production to reach 90,000 tons of triple super.

Simplot is the first in the area to undertake production of concentrated phosphate fertilizer, despite the fact that Idaho has about 85 percent of the nation's known phosphate reserves. Other manufacturers turn out elemental phosphorus in electric furnaces and single-strength fertilizer by acidulation.

Simplot, which began operations in 1944, will continue to produce 19 percent phosphate fertilizer, for which its rated annual output is 200,000 tons, in addition to the 45 percent phosphate product.

To ready its plant for production of triple superphosphate, Simplot spent about $850,000. New filters for phosphoric acid production were installed, together with acidulating and concentrating equipment. Existing rock crushing, pulverizing and storage equipment is being used, as are screening and sacking facilities.

Simplot, which furnishes Westvaco Chemical with raw phosphate shale for its electric furnace, leases the Gay

mine on the Fort Hall Indian reservation. A 23-mi. spur line connects the mine with the two plants in Pocatello. This makes possible better utilization of the phosphate deposits since Westvaco can process low-grade rock in its electric furnace, while Simplot uses the high-grade material for acidulation.

Ethyl Producing 2,4,5-T At Its Houston Plant

Staking a larger claim in agricultural chemicals, Ethyl Corp. is now producing the herbicide 2,4,5-T commercially in its Houston, Tex., plant.

Besides 2,4,5-T, Ethyl produces benzene hexachloride, or BHC, and is currently completing a plant to make lindane, which is derived from BHC.

The chemical 2,4,5-T, or 2,4,5-trichlorophenoxyacetic acid, is a hormone-type weed killer. It speeds the growth processes of plants, especially broad-leafed woody plants, causing them to die.

Ethyl produces 2,4,5-T as the acid and as the butoxy-ethoxy-propanol ester for use in low volatile ester formulations. Ethyl will market its product to compounders of agricultural chemicals, who formulate herbicides. The 2,4,5-T is used alone or with 2,4-D.

Chemical Industry Arises In Calvert City Area

Calvert City, Ky., is fast becoming an important chemical center. Three new plants are now getting into full operation there. These are the \$8 million chlorine-caustic plant of Pennsylvania Salt Manufacturing Co., the \$10 million calcium carbide and acetylene generating plant of National Carbide Co., a division of Air Reduction Co., and the \$8 million vinyl chloride plant of B. F. Goodrich Chemical Co.

Together with the plant of Pittsburgh Metallurgical Co., second industry in the area, and Pennsalt's hydrofluoric and sulfuric acid facilities, the first plant in Calvert City, which was completed in 1949, the total of new industrial investment in the area now exceeds \$30 million. About \$9 million of new construction is currently being added to present facilities and further additions are contemplated.

Pennsalt's new chlorine-caustic

plant uses the new De Nora mercury cells, developed in Italy and licensed in the U. S. by Monsanto Chemical Co.

The new Calvert City plant of Pennsalt can turn out 50 tons of chlorine daily, together with a proportionate amount of caustic soda and hydrogen. This plant includes a unit for producing pure anhydrous hydrogen chloride gas.

Air Reduction's calcium carbide and acetylene plant, which only started operating this year, is already undergoing an expansion that will double its rated yearly capacity of 142,500 tons of calcium carbide. Two added furnaces are now under construction and are expected to be operating in 1954. Large quantities of calcium carbide will be shipped from Calvert City to the neoprene plant of Du Pont in Louisville, Ky., adding to output from Airco's Louisville carbide plant.

Goodrich is now producing vinyl chloride monomer at Calvert City. Its output goes by tank car to the Goodrich resin plants at Avon Lake, Ohio, and Louisville.

Stancal Getting Another Giant Vacuum Flasher

Another vacuum flasher will be erected by M. W. Kellogg Co. at the El Segundo, Calif., refinery of Standard Oil Co. of California.

The unit, with a capacity of 55,000 bbl. of reduced crude daily, equals in capacity a similar plant Kellogg designed and erected for Standard of California over a year ago at its Richmond, Calif., refinery. These vacuum flashers are the world's largest.

Part of a major refinery improvement program at El Segundo, the new vacuum flasher will be under construction by July.

Lion Oil's Ammonia Plant Rising in Louisiana

Construction is progressing on the $31 million chemical plant of Lion Oil Co. at Luling, La., and the plant will be in operation in the second quarter of 1954.

It is designed to make 300 tons of anhydrous ammonia per day. It will convert 250 tons of this ammonia into 550 tons of pelleted ammonium nitrate. The other 50 tons of ammonia produced daily will be marketed.

Nitric acid for making the ammonium nitrate will be manufactured in

a unit with a daily capacity of 430 tons of acid.

This new chemical plant will increase Lion Oil's annual production of nitrogen by 90,000 tons annually. This is more than 50 percent. Lion Oil has a chemical plant at El Dorado, Ark., which produced 198,722 tons of anhydrous ammonia last year.

Lion Oil's new ammonia plant will bring investment in petrochemicals about in balance with that in its oil operations. In 1952 Lion Oil had 818 producing wells with an output of 11,192,876 million cubic feet of natural gas and 7,713,422 bbl. of crude oil.

The new plant at Luling is situated on a 1,400-acre site about 14 mi. upstream from New Orleans on the west bank of the Mississippi.

Chemical Industry Paces Expansion Boom in Dixie

The South added an average of one new multi-million dollar manufacturing plant per day during 1952, among them many new chemical plants. That's the finding of the Southern Association of Science and Industry, which has just surveyed Dixie's growing industry.

Pace of growth in the South, declares President James F. Crist of SASI, is continuing and a greater variety of manufacturing plants are locating there. Crist is president of Gulf Power Co. and vice president of the Southern Co.

Southern industry, the SASI reports, now comprises more than 12,500 manufacturing plants employing 50 or more workers.

Growth of chemical industry in the South has been rapid. Dixie now has 38 acid plants, 17 ammonia, 22 caustic soda plants, 133 manufacturers of industrial chemicals, 23 chlorine plants, 20 producers of sulfur and 17 producers of salt brine.

In addition, there are 22 asphalt plants, 20 makers of batteries, 208 fertilizer plants, 51 naval stores installations, 44 paint and varnish plants, 72 pulp and paper mills, 35 pharmaceutical plants, 17 plastics producers and 151 petroleum refineries.

The South, says President Crist of SASI, is now a rich market for many industrial and chemical products. SASI, with headquarters in Atlanta, Ga., seeks to accelerate the development of the South's markets.

LOW SUDSING

and good wetting at low concentration

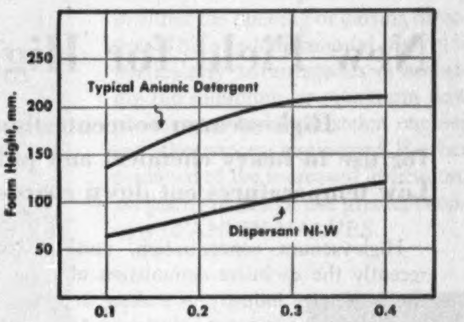
New Nonionic Surfactant

If you have an operation requiring a surface active agent, but where "suds" or "foam" are a handicap, it will pay you to investigate Oronite's new water-soluble Dispersant NI-W. It will solve this problem for you.

Because NI-W is in the chemical class of alkylphenyl polyethoxyethanols, it is both heat and chemically stable. It is effective in hard or soft water. It is completely compatible with soaps, anionic detergents and cationic germicides.

NI-W may be compounded with phosphate or other builders and dried to give free-flowing granular products. Suitable also for making liquid detergents. NI-W is a very adaptable product for the manufacture of economical high-quality formulations.

Available in inner-coated drums or tank cars for product purity. Technical bulletin and sample available on request.



ROSS-MILES FOAM TEST

SOLUTION TEMPERATURE 110°F—WATER HARDNESS 300 ppm

* The above chart shows, that at equal concentrations, the foam created by Dispersant NI-W is only about half as high as when a typical anionic detergent (alkyl aryl sodium sulfonate type containing approximately 40% active ingredient) is used.

ORONITE CHEMICAL COMPANY

THE NAME TO WATCH IN CHEMICALS

A partial list of Oronite products:

Detergent Alkane, Detergent Slurry, Detergent D-40, Detergent D-60, Dispersant NI-O (oil-soluble emulsifier), Dispersant NI-W, Wetting Agents, Lubricating Oil Additives, Cresylic Acids, Gas Odorants, Sodium Sulfonates, Polybutenes, Naphthenic Acids, Phthalic Anhydride, Ortho-Xylene, Xylol, Aliphatic Acid, Hydroformer Catalyst, Dispersant FO (Domestic Fuel Oil Inhibitor)

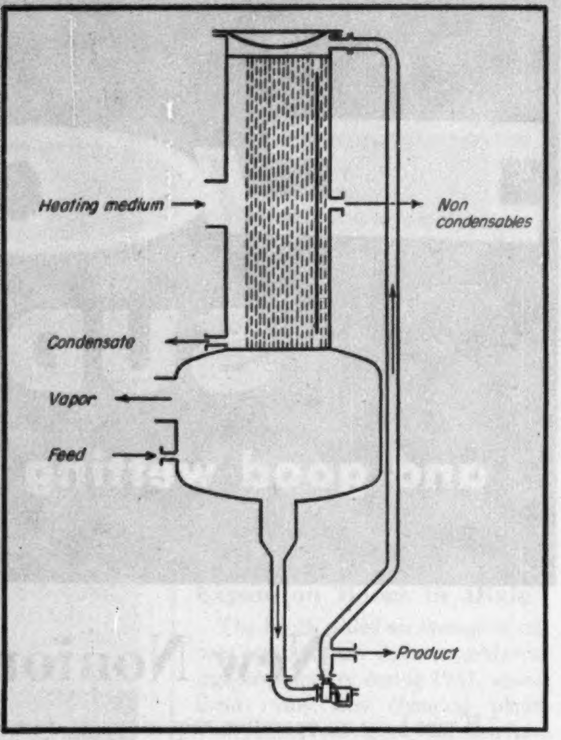
"The world's largest producer of synthetic detergent raw materials"

ORONITE CHEMICAL COMPANY

38 SANSOME STREET, SAN FRANCISCO 4, CALIFORNIA
30 ROCKEFELLER PLAZA, NEW YORK 20, NEW YORK
STANDARD OIL BLDG., LOS ANGELES 15, CALIFORNIA
600 S. MICHIGAN AVENUE, CHICAGO 5, ILLINOIS
MERCANTILE SECURITIES BUILDING, DALLAS 1, TEXAS

2019

This high vacuum concentrator built by Carrier . . .



. . . operates on the falling film principle.

New Field for High Vacuums

High-vacuum concentration is now being considered for use in heavy chemical and pulp processes. Big reason: Low temperatures cut down corrosion and limit scaling.

High-vacuum concentration, until recently the exclusive commission of the fruit juice industry, is making inroads into the process industries. At present, pharmaceutical people are showing the chief interest in it—they're using high vacuums right now for the concentration of antibiotics.

However, high-vacuum concentration may have equally important applications in heavy chemicals and pulp; for example, in the concentration of black liquor, caustic soda, magnesium chloride and wet-process phosphoric acid. In fact, Western Phosphate's new acid plant at Garfield, Utah, will have a high-vacuum unit.

High vacuums can cut costs in all these operations, claims Carrier Corp., Los Angeles, who has been doing extensive work in the field. Since corrosion rates are reduced, cheaper materials of construction can be used, Carrier explains. Also, because scaling difficulties are diminished, heat-transfer rates are increased.

"We have concentrated caustic soda to a 35-percent solution," says Manager E. J. Kelly of Carrier's concentrator department, "and the material of construction could have been mild steel." At this concentration the temperature of the caustic solution is not in excess of 150 deg. F.

In the concentration of magnesium chloride, too, materials of construction need not be a serious problem. At elevated temperatures magnesium chloride solutions tend to break down and liberate corrosive HCl gas. However, with high-vacuum concentration no breakdown occurs.

How does high-vacuum concentration prevent corrosion? In two ways, says Kelly:

- It operates at lower temperatures, and corrosion rate varies directly with temperature. Tests have been conducted with mild steel in a salt solution of a given concentration and plots made of corrosion rates vs. temperature. Results show, by reducing temperatures from 60 to 20 deg. C. corrosion rate falls from 0.045 cm. per yr. to 0.010 cm. per yr. In other words, corrosion at 20 deg. C. is only one-fourth that at 60 deg. C.
- It operates at reduced velocities, and corrosion varies directly with velocity. Engineers studied the effect of a liquor being circulated at various velocities in an atmosphere of air on iron. They discovered that corrosion rate can be reduced 25 percent by reducing velocity from 9 to 3 ft. per sec.

In the Carrier process, velocity is low because only the force of gravity minus frictional resistance acts on the liquor to be concentrated.

▶ **Less Scaling**—Besides economies in materials of construction, low-temperature operation can reduce scale formation. For example, some scale-forming calcium and sodium salts, big headaches in chemical processing, have inverted solubility curves. As temperature increases, solubility decreases, and

scale forms on the heat-exchange surface. As a result of pilot tests, Carrier has shown that downtime for scale removal can be reduced by as much as 50 percent.

In addition, while concentrating black liquor from 10 to 50 percent solids at 100 deg. C., Kelly found that operations could be sustained for periods of 60 or more hours with only a slight decrease in heat-transfer capacity.

Similar experiments have been made with brine concentrations. Here the main scale-former is calcium sulfate, which in conventional concentration processes separates as a hard scale. This scale usually forms almost as soon as the evaporator is put into operation and continues at such a rate that the evaporator has to be shut down and the scale mechanically drilled out of the tubes.

"By using high-vacuum concentration the formation of scale can not only be reduced," says Kelly, "but whatever scale does form, forms as a soft scale that is easily washed away."

► **How It Works**—The Carrier concentrator is essentially a vertical falling-film evaporator (see cut). Liquor to be concentrated is pumped above the top tube sheet and falls in a thin film down the tube walls. In a typical case the tubes are 3 in. in diameter. Vapor and concentrated liquor are separated by a baffle arrangement.

Heating medium is warm water at about 90 deg. F. This water gets its heat by condensing the refrigerant in the auxiliary refrigeration unit. After giving up its heat to the concentrator it returns to the refrigeration condenser for rewarming.

Purpose of the refrigeration unit is to supply chilled water, at about 37 deg. F., to a barometric condenser handling the vapors from the concentrator. The water is chilled by heat exchange with a suitable refrigerant, such as Freon-11. It is recycled from the condenser cold well back to the refrigeration unit.

Several concentrators can be hooked up in a conventional multiple-effect arrangement, with vapor from the first effect condensing in the second effect as the heating medium, and so on.

Pressures in the range of 10 mm. Hg absolute are usually maintained with a three-stage steam-jet ejector backing up the barometric condenser.

Lower pressures may be used if necessary, requiring substitution of a brine or refrigerant-cooled surface condenser for the chilled water-cooled barometric condenser.

▶ **Howard to Carrier**—While Carrier is the present manufacturer, it was not the original developer of this concentrator. That credit goes to C. E. Howard Corporation. Carrier bought exclusive rights to the process in 1949.

Howard developed the process primarily for citrus application. But Carrier, attempting to improve the process, has attacked the problem of concentrating other materials. Results, while not spectacular, have been encouraging. For instance, Carrier engineers, in conjunction with pump manufacturers, have perfected pump seals for handling corrosive liquors under extremely high vacuum and have developed pumps for handling highly viscous fluids.

In addition, correlations between vapor velocities, evaporation rates and tube diameters have been made. "As a result," says Kelly, "we can now vary tube size with operating conditions to give an optimum length-diameter ratio to allow the equipment to function on low temperature differences that were heretofore considered impossible."

New Xylene Plant Part of Expansion at Refinery

A catalytic cracker and para-xylene plant will be built at the El Segundo, Calif., refinery of Standard Oil Co. of California.

Fluor Corp. of Los Angeles will build the cat cracker, which will handle 40,000 bbl. per day, and also the para-xylene plant. Fluor will also expand the alkylation plant and alter the naphtha rerun stills.

A residuum stripper, with a capacity of 52,000 bbl. per day, will be erected by M. W. Kellogg Co. of New York, while Macco Corp. of Paramount, Calif., will install other facilities.

Monsanto Steps Up Output Of Vinyl Butyral Plastic

Monsanto Chemical Co. will expand production of vinyl butyral interlayer by 50 percent to keep pace with the auto industry's growing demand for laminated safety glass.

The new expansion, according to Robert K. Mueller, general manager of Monsanto's plastics operations at

Springfield, Mass., "follows hard on the heels of a 20 percent increase completed earlier this year." Largest of the three suppliers of the plastic interlayer, Monsanto now serves about 60 percent of the U. S. market.

Monsanto makes the plastic in clear sheets or in the new graduated green tints. Sandwiched between two sheets of glass, the clear plastic is virtually invisible to the motorist.

Working with the glass companies to produce a windshield that reduced sun glare, Monsanto developed a method for graduating the coloring of the vinyl butyral interlayer.

The expansion at Springfield will give Monsanto extra capacity to meet peak loads imposed from time to time by the automotive industry.

Demand for vinyl butyral in safety glass is growing. Every state now requires safety glass in auto windshields. And windshields are getting bigger. It's estimated cars in the future will have 50 percent more safety glass.

Advantage of the laminated safety glass lies in the adhesion of the glass to the plastic when struck by an object or shattered in a collision. The risk of injury or death from flying splinters is materially reduced by sandwiching between glass layers the vinyl butyral.

New Corrosion Testing Service

Kenneth Tator Associates, Coraopolis, Pa. announces the establishment of a custom corrosion testing service for industrial environments. Here, for the first time, selected industrial exposures, under rigorous control, are made available to manufacturers of industrial coatings and other corrosion mitigating methods for objective testing of their products.

Heretofore exposures to atmospheric and marine environments have long been available and proven invaluable to industry. However, the complexity and variety of industrial exposures have discouraged efforts for product testing in these atmospheres.

A similar Kenneth Tator Associates service has been functioning efficiently for over four years for clients who are national chemical manufacturers and coatings users. That client service now is duplicated to include a custom service to the manufacturers of coatings and corrosion

control methods. This new custom testing service uses entirely separate facilities from the client service in its operations.

Numerous requests by suppliers for performance information on their products, which Kenneth Tator Associates has not heretofore been free to divulge from their user clients, has been given the credit for launching the new offering.

All the new custom test stations are located in the plants of large industrial companies. Exposures are made directly to plant fume environments such as organic and mineral acids, ammonia, organic solvents, entrainment of corrosive chemicals, high humidity conditions, radiant heat, salt, mildew, and heavy industrial. Other stations are to be added as demand develops.

In operation, the new service will entail periodic inspections and submission of progress reports to subscribers. This is handled by a fixed installation charge and a supplementary monthly charge; the latter is applicable only for the duration that client's desired panels remain in test.

Products benefited by evaluation at the Kenneth Tator Associates test facilities are: adhesives, coatings, fabrics, leather, metals, paints, paper, plastics, roofing, rubber, and wood preservatives.

Generators Purify Gases For Synthesis of Ammonia

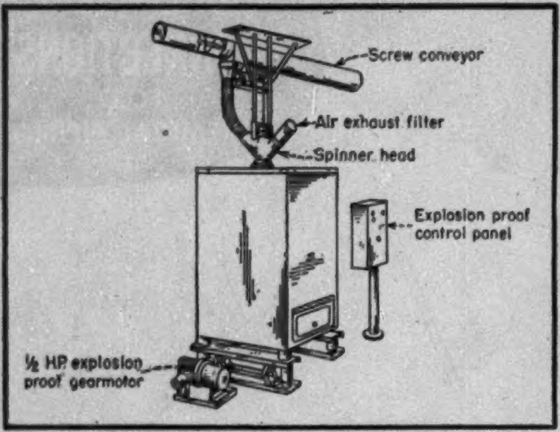
Two nitrogen and two hydrogen purification generators that can produce enough synthesis gas for 235 tons of ammonia daily have been sold by Air Products, Inc., of Allentown, Pa., for installation on the West Coast.

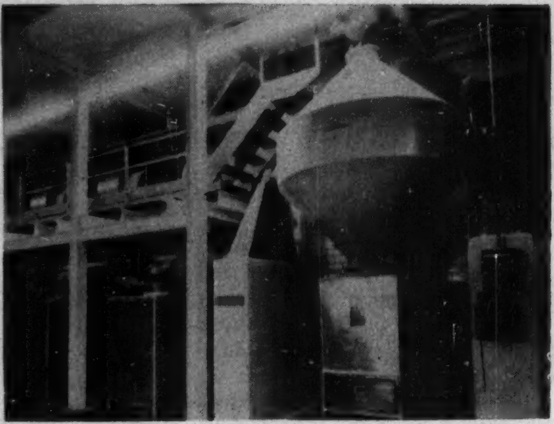
The generators will go into the new Brea, Calif., plant of Brea Chemicals, Inc. The plant will use a low-temperature process in the purification of both hydrogen and nitrogen.

C. F. Braun & Co. of Alhambra, Calif., will install the generators in the Brea ammonia plant. The ammonia plant is next to the research laboratories of Union Oil Co., of which Brea Chemicals is a subsidiary.

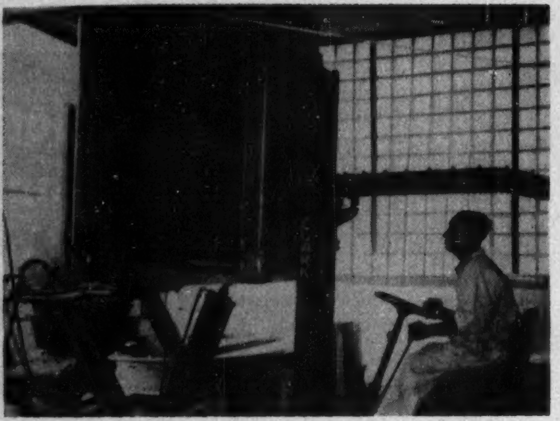
Brea will use the output of its ammonia plant for fertilizer. Its marketing area will be the southwestern United States.

Air Products will deliver the four generators at the Brea plant site, which is about 30 mi. east of Los Angeles, some time this fall.

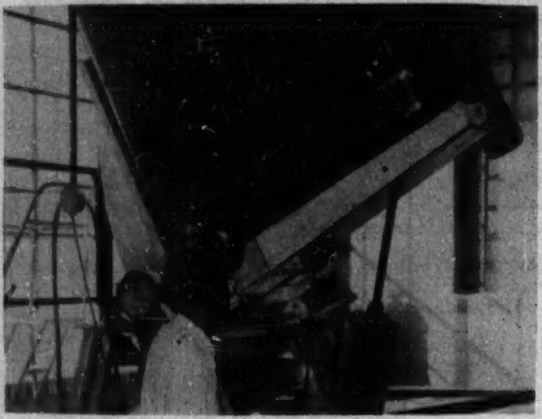


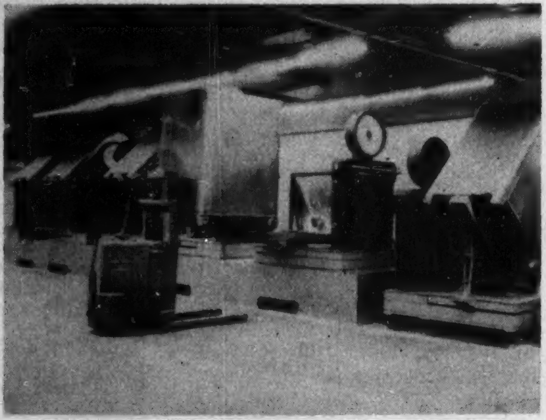


FILL IT: Two suggested methods, both simple and dustless. Cut at right shows GE plant.



TOTE IT: At left, unloading the bins; at right, placing them on the discharge rig. (National Plastic Products plant.)





DUMP IT: At left (National) molding materials ready for discharge; at right, GE's plant. Shut-off controlled by pre-set weight.

No Dust, Nó Waste, No Heavy Labor

Chemical materials take a good idea from food-handling plants

TOTE SYSTEMS

Materials handling engineers are watching keenly the growing application in chemical process plants of a system for moving bulk solids which has already found wide acceptance in the food processing industry. Known as the Tote System, it is based on the use of portable bin boxes which can be transported from point of filling to point of discharge with fork-lift or pallet trucks.*

Here are two typical chemical process installations. One was recently put in by General Electric at its Chemical Products Works, Lamp Division, in Cleveland; the second is in the Odenton, Maryland, plant of the National Plastic Products Co. GE's is an intraplant installation; the National Plastics job is an example of inter-plant handling of bulk materials.

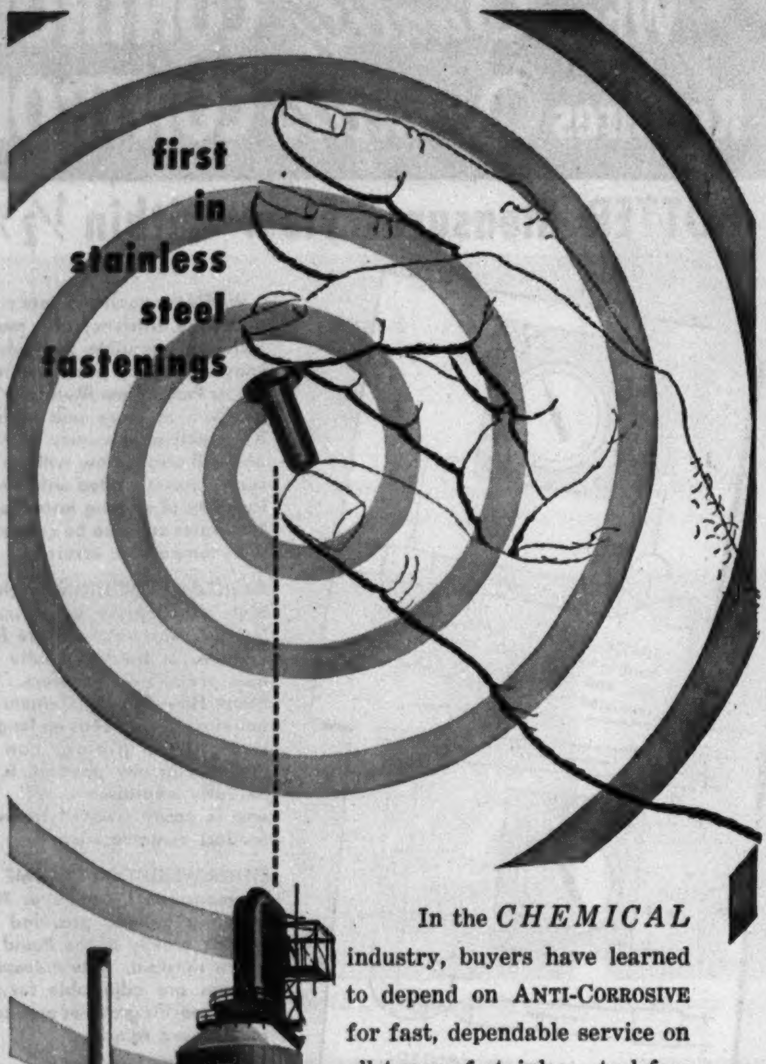
▶ **The Old Way**—GE's problem was handling precipitated calcium acid phosphate and carbonate, and fired complex calcium phosphates. These materials (moved from step to step within the plant from manufacture to packaging) are less than 15 microns in particle size.

All handling and storage used to be done in 4-cu.-ft. standard fiber drums. This system had many disadvantages:

- Transfer of the powdered chemicals to and from process equipment was an unusually dusty operation. The dust—although not toxic—was quite irritating. It was also too valuable to be drawn out through ventilating systems.
- Low capacity of the drums made it necessary in some cases to shovel into them from shallow boxes large enough to accept cascade discharges from conical blending equipment.
- Chemical contamination was a problem. Introduction of residual rust had to be avoided. Extraneous material was sometimes found in the process equipment, introduced usually through the general use of the open drums.
- Use of a large number of small containers made greater opportunities for errors of various sorts.

▶ **The New Way**—Six months ago, the plant completed installation of the Tote system (*see cuts*). Basically the system is engineered around the tightly-sealed, 74-cu.-ft. aluminum bin. This, together with bin-filling

* It's marketed by Tote System, Inc., Beatrice, Nebraska. For details of how it works see Chem. Eng., May 1952, p. 210.



and bin-discharging apparatus, comprises the Tote system. Bins are on 4-in. legs to permit ease of handling with fork lift or pallet trucks; are carefully designed for warehousing or grouping with no waste space.

After installing this system GE found that one 74-cu.-ft. bin could replace up to 20 drums.

In one instance of blending, five Tote bins are handled instead of 120 fiber drums. The Tote bin in use at this plant is 3½ x 4 x 5¾ ft. and is used for loads up to 4,400 lb. (The standard-size Tote bin has an average loaded capacity of 3000-4000 lb. depending on the bulk density of the material handled.) GE uses the bins in a minimum of eight separate steps during processing.

▶ **Cost and Savings**—The entire installation, 100 bins plus 16 tilts with auxiliary conveyor, chutes, steel, wiring and scales, cost $95,000.

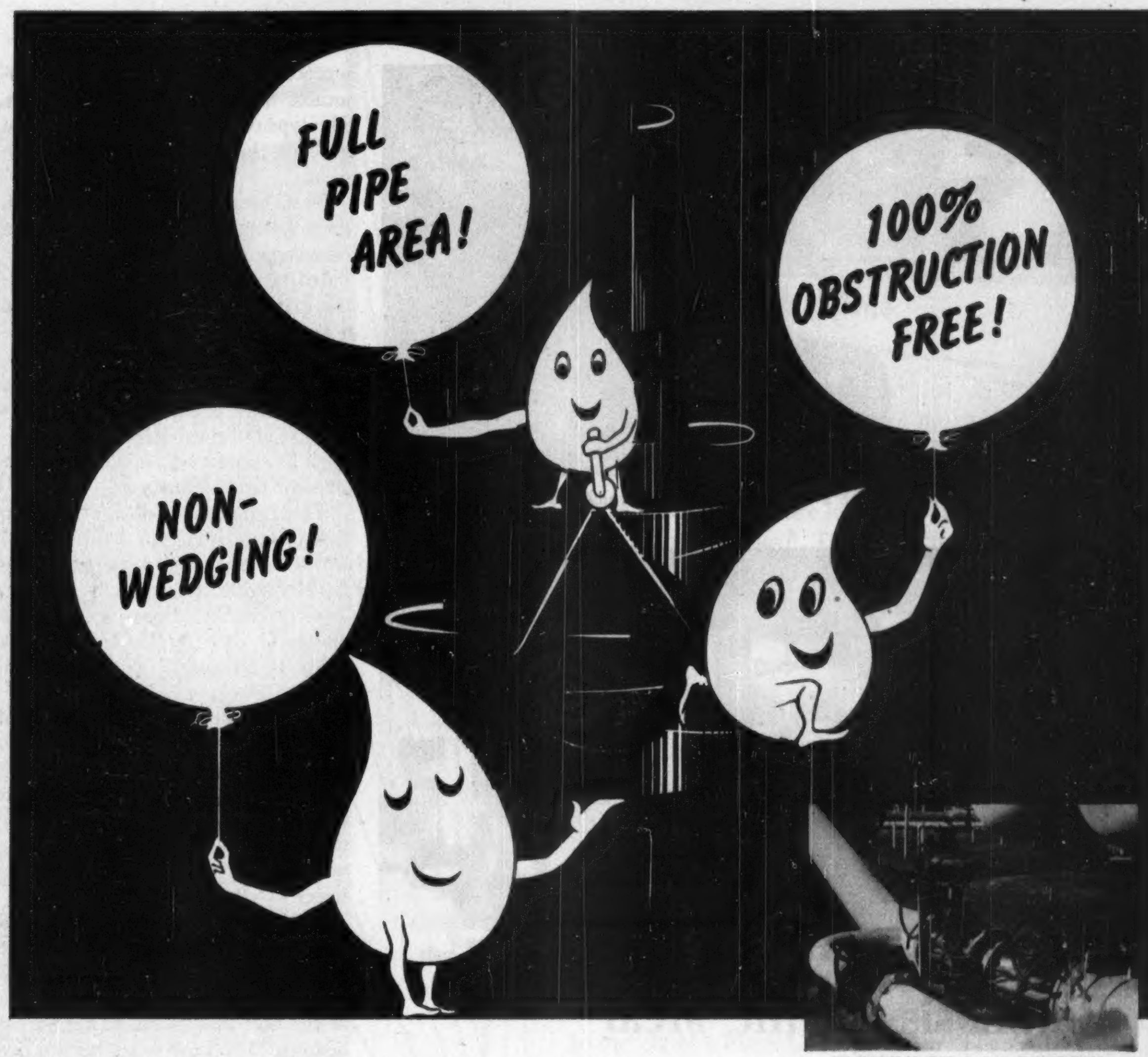
Besides material savings of $10,000 a year (the extent of former dust losses in strongly-ventilated transfer points and as contaminated product), GE estimates that direct labor cost is cut $16,000. (Tote System claims that a carload of Tote bins can be unloaded in less than 1 man-hr. instead of the 8-14 man-hr. needed to unload the same volume in bag shipments.) In addition GE hopes that the closed system will minimize medical problems from airborne dust.

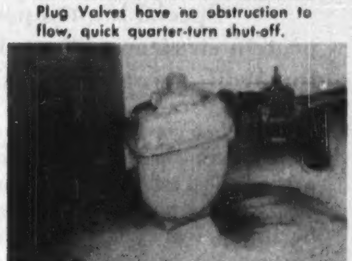
▶ **Plastics Plant**—National Plastics uses Tote bins to bring in molding materials and resins from its source of supply. Five company-owned trucks, each handling 15 bins (1,100 cu. ft. of material) make the 1,500-mile round trip in accordance with production schedules.

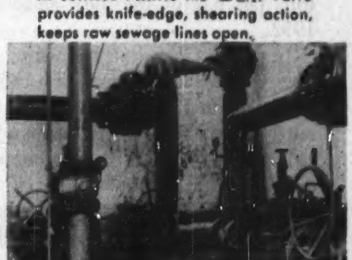
Switching from bags and fiber drums to the aluminum bins for handling molding materials, the company has racked up a number of benefits:

- Bulk discount from the supplier through elimination of disposable containers.
- Lower handling costs.
- Less warehouse space needed.
- No product loss, no dust or spillage during handling.
- No product contamination.

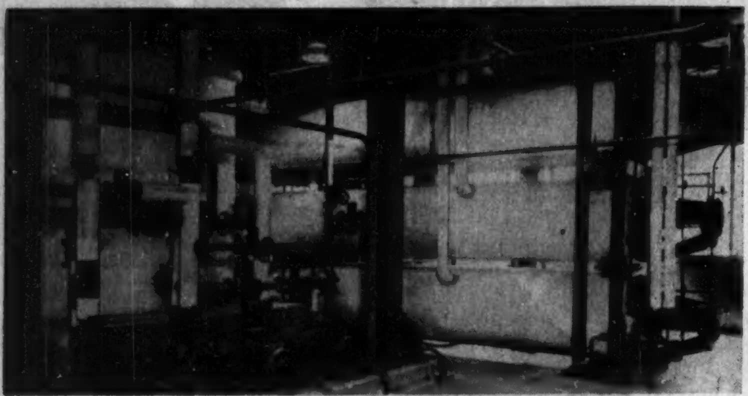
▶ **Bin for Liquids**—Latest word from the Tote organization is about a new modified bin for liquids. It has a 315-gal. capacity and is said to have clear-cut advantages and economies over conventional 55-gal. drums.


FULL PIPE AREA!
100% OBSTRUCTION FREE!
NON-WEDGING!





AMBIENT TEMPERATURES in the extractor, top of which is shown, and . . .



VACUUM and low temperatures in desolventizer distinguish process which puts . . .

Emphasis on the Meal

Special low-temperature extraction process preserves protein structure, allows Britain to use peanut meal as base for Ardil, a wool-like synthetic fiber.

Textile-hungry Britain is now successfully using peanut meal to make a protein fiber called Ardil. A continuous solvent extraction plant operated by British Extracting Co. in Bromborough has been turning out 100 tons per day of the meal since early 1952.

Imperial Chemical Industries converts the extractable protein into Ardil at a plant in Dunfries, Scotland. Currently producing 10 million lb. a year, the plant is expected to double its output before long.

▶ **Reverse Twist**—Although the extraction plant is not new in principle, it has novel features essential for Ardil fiber protein. Usually solvent extraction plants are engineered to get the highest possible yield of oil. But an unorthodox task faced the British designers. They had to tailor their equipment and operating conditions to assure the desired properties in the residual meal.

Their outstanding problem was to see that the oil was extracted from the peanuts—"groundnuts" to the British—at comparatively low temperatures. The penalty for failure would have been irreversible denaturing reactions of the protein in the meal. Normally a help in the extraction of oil, these reactions destroy the meal's usefulness in fiber manufacture.

About 80 percent of the oil is removed from the nuts by low-pressure continuous screw pressing. Skillful precooking renders cell walls more permeable without harming the protein. The type of screw press used does not generate high temperatures in the meal.

Next, breaker rolls reduce the meal, then flaking rolls blend it to a thin membrane which can be easily penetrated by the hexane solvent used for the extraction.

▶ **At Ambient Temperature**—The normal extraction plant operates at temperatures between 40 deg. C. and the boiling point of the particular solvent used. But the extractor at Bromborough has been made to do its work at ambient temperature.

The extractor is of the Bollman type (*Chem. Eng.*, Jan. 1951, p. 129) which is essentially a large bucket elevator within a gas-tight housing. Though its dimensions are approximately 11 by 9 by 53 ft. high, only 1 hp. is consumed in operating th unit.

An automatic feeder delivers meal to the buckets. Solvent sprays into each bucket near the top of the casing on each side. Initially, the solvent washes most of the oil out of the meal in parallel flow. A final washing in counterflow removes the remaining traces of oil.

Clean solvent is used on the countercurrent side of the extractor. The buckets are flooded in turn and the solvent drains through a gauze filter in the bottom of each to the bucket beneath. The weak miscella from this part of the process collects in a compartment at the foot of the extractor. After being pumped through a filter it is used for initial washing of the fresh meal in the descending buckets. The resulting oil-saturated solvent known as full miscella is collected in another compartment and drawn off for distillation.

As each bucket completes a full circuit it is automatically inverted and discharges the meal to a small hopper. The full cycle for one bucket usually takes a little over 2 hr.

▶ **Vacuum Desolventizers**—Meal leaves the vapor-tight casing and goes to the desolventizers. Here again, need to preserve the proper protein structure limits the allowable rise in temperature.

Typical temperatures for desolventizing meal are about 100 to 110 deg. C. and pressure is usually atmospheric. At Bromborough, this step is carried

out below 60 deg. C. and at a vacuum above 10 in.

Six horizontal steam-jacketed tubes in a vertical bank make up the lower section of the unit. Extracted meal comes into the top tube through a rotary sealing valve from a small buffer bin. A similar rotary valve is fitted at the outlet from the bottom tube. Stirrers move the meal along each tube in turn, freeing the vapors, which pass on to condensers. At each shaft end are lantern glands to insure proper seals.

Conveyors take the dried meal to another building where it is cooled and screened. Larger fragments are ground to a size acceptable for Ardil production.

This new fiber source is a welcome addition to the U. K. textile supply, which has fallen off considerably since the war while consumption has been rising. ICI has also been investigating ways and means of marketing Ardil in the U. S.

▶ **U. S. Counterpart**—The nearest this country comes to the wool-like Ardil fiber is Vicara (**Chem. Eng.**, April 1952, p. 224) produced by Virginia-Carolina Chemical Corp. Total capacity of the company's three plants is placed at 12 mililon lb. a year. The U. S. process uses zein (a byproduct of our corn starch industry) as a raw material.

Ammonia Plant Gets New Welded Scrubbing Towers

Four new water scrubbing towers have been installed in the purification area of the Hopewell, Va., plant of Allied's Nitrogen Division.

The new towers are of all-steel welded construction. Each is 85 ft. high, 6 ft. in diameter, and about 70 tons in weight when empty and 90 tons when filled with aluminum rings.

The towers are used to remove carbon dioxide from the gas used for making ammonia. Gas laden with carbon dioxide is forced through water, and the water absorbs the carbon dioxide. The rings serve to disperse the water as it falls and thus expose more of it to the gas.

It took three flat cars in tandem to carry each tower to Hopewell. And installation of each tower by Nitrogen Division crews required about nine days.

When the old scrubbers were in-

stalled, as original equipment at the plant, they were among the heaviest riveted vessels made. In service since 1928, they are now replaced by the new welded towers.

Monosodium Glutamate Made From Molasses Residue

Monsodium glutamate will be produced from sugar beet residues at a $25 million plant to be built at Johnstown, Colo., by the Great Western Sugar Co.

President Frank A. Kemp says Great Western is "convinced by 20 years of research that it will be profitable for us and will play an important role in the expanding economy of the Rocky Mountain states".

The plant will be next to Great Western's molasses refinery at Johntown, and will get its raw material for glutamate manufacture from the molasses refinery.

"Our source of monosodium glutamate will be certain residual liquids which are byproducts of the sugar extracting processes," says Kemp.

At present, other manufacturers are extracting monosodium glutamate from wheat gluten and corn gluten.

The new plant will produce a molasses-type livestock feed as a byproduct. It will contain a high concentration of essential nutrients.

Great Western first produced monosodium glutamate from molasses residue in a pilot plant at Longmont, Colo., in 1943. This pilot plant was expanded in 1945. A semi-commercial plant has been operating successfully at Great Western's Loveland, Colo., plant since 1950.

The new plant at Johnstown will be ready to run in November 1954. It will employ 135. Great Western won't estimate production "until actual operation begins."

Extractive Distillation Gives High Benzene Recovery

Atlas Processing Co. is efficiently producing high-purity benzene at its Shreveport, La., aromatics recovery plant. This was the first plant using the extractive distillation process of Shell Development Co. to be built and operated in the U. S. since the end of World War II.

Benzene recovery of more than 98 percent has been demonstrated since the plant went on stream late last year. The extractive distillation and solvent

WHAT'S HAPPENING, *cont. . .*

stripping sections have shown benzene recovery efficiency as high as 99.9 percent.

The product benzene possesses high purity. It has an ASTM solidification point of 5.42 deg. C., compared with 5.53 deg. C. for pure benzene.

Moreover, the benzene does not have to be treated when processing the raw naphtha charge, which consists of natural gasoline of about 10 lb. RVP. In fact, the solvent carryover into the final benzene product is so low that it doesn't have to be removed for the benzene to meet nitration-grade specifications.

Economy of the process is enhanced by the low rate of solvent losses. These amount to about 0.018 lb. per bbl. of finished benzene.

The Shreveport plant has a charge capacity of 15,000 bbl. per day.

Device Records Changes In Atmospheric Fluorides

Accurate and continuous tracking of atmospheric fluorides is possible with a new device developed at Stanford Research Institute.

It accurately detects hydrogen fluoride and continuously measures parts per billion of gas in the atmosphere.

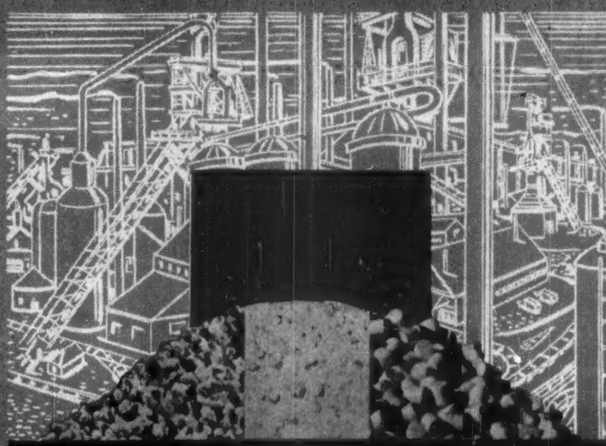
Detection is made on a roll of filter paper impregnated with a fluorescent metal salt. Contact with the slightest trace of HF gas diminishes the fluorescence.

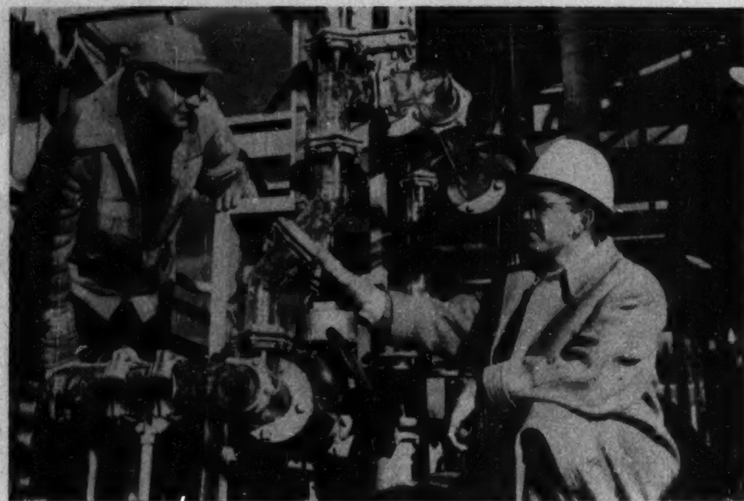
As the tape slowly unwinds from one spool to another, only part of the moving surface is exposed to the atmosphere. Variations in fluorescence are measured photoelectrically, and results are graphed on a continuous recorder. The SRI instrument is designed to record fluctuations over several days. It can be left unattended in the field.

Present sampling methods accumulate the gases from the air for several hours and measure the average intensity. Thus extreme highs or lows of concentration pass unmarked.

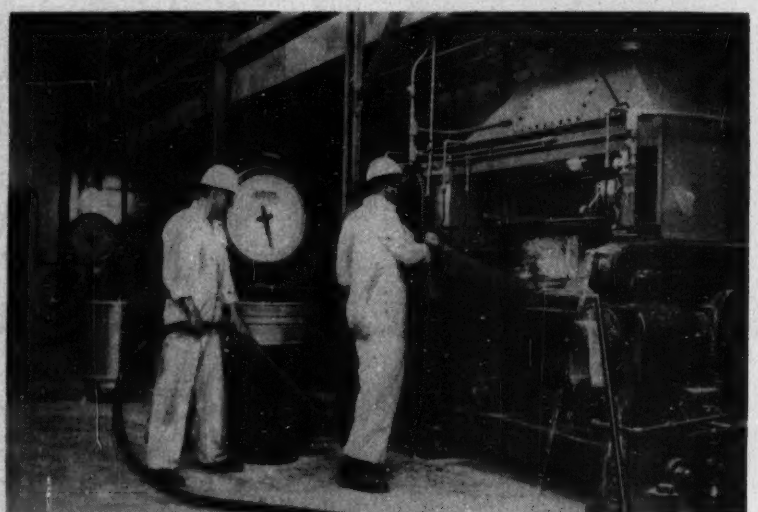
Certain emissions from manufacturing plants may raise the atmospheric fluoride concentration to a high level. And it takes only several parts per billion to damage vegetation.

Dr. Saul W. Chaikin of Stanford Research Institute developed the recorder. Four industrial companies helped to support the work, which took a year.





GLASS PIPING is used to recover hydrochloric acid in one of the plant's new units.



RUBBER MILL, one of several installed as part of the Waterford expansion.

GE Expands Silicone Plant

Faced with an expected tenfold increase in demand for silicone products by 1960, GE has sunk $5 million into expanding its Waterford, N. Y. plant.

Silicone Products department's general manager, Charles E. Reed, says that the expansion will help the company relieve current shortages of its present line of silicones—and look into new products as well.

Keeping an eye on the terrific demand for things like silicone rubber (tripled in the last two years), the company is already planning further expansions of the six-year old Waterford plant.

GE makes the versatile sand derivatives in a variety of physical form from volatile liquids to heat-resistant solids. Among the products produced are silicone rubber gums and compounds, fluids for automotive and furniture polishes and mold releases, resins for electrical insulation and paint, anti-foams for liquid systems, and water repellents for such widely differing materials as masonry and textiles to name just two.

Duct connection on side leaves ends free for access!

one of many plus features in these...

ELLIOTT forced-ventilated squirrel-cage MOTORS

No need to disconnect and remove the ventilation duct to get at the bearings and remove brackets of this motor.

This squirrel-cage induction motor is rated 300 hp, 500 rpm, 3 phase, 50 cycle, 2300 volts and 50°C rise. It is one of a group for a specialized application, and typifies the facility with which the welded steel enclosure design of large Elliott motors lends itself to easy modification for specific conditions. Duct opening on the side takes incoming air, and on the opposite side a similar opening covered with a plate can be used for emergency ventilation should the forced ventilating system be inoperative. Installed at high altitude, corona effect at rated voltage is neutralized by special insulation.

For details on these and other Elliott motors, contact your local Elliott representative or write Elliott Company, Ridgway Division, Ridgway, Pa.

ELLIOTT Company

RIDGWAY DIVISION

R3-9

Automatic Plant Will Make Catalyst for Cracking

Production of synthetic petroleum cracking catalyst is just getting under way at the new $7 million plant of Davison Chemical Corp. at Lake Charles, La., dedicated recently by Governor Robert F. Kennon of Louisiana.

The plant will manufacture 45 million pounds per year of petroleum cracking catalyst, enough to process more than 200 million barrels of petroleum.

Davison's new Lake Charles plant exemplifies the trend toward automatic operation. It will run 24 hr. a day, seven days a week, and will require only nine men per shift, stationed at five large instrument panels, to control the entire manufacturing process. Their job will be mainly to keep check on the smooth functioning of the process, as revealed by instruments on the panels.

Other employees are needed for maintenance, quality test and control, material handling, and office and clerical work. The payroll, exclusive of executives, will total about 160.

Davison in 1942 pioneered large-scale manufacture of fluid synthetic petroleum cracking catalyst at its Curtis Bay plant in Baltimore. These facilities were later expanded and another plant acquired in Cincinnati. With the opening of the Lake Charles plant, Davison's total production capacity for this product will exceed that of all the rest of the industry.

With the opening of the Lake Charles plant, Davison will become for the first time a producer of sodium silicate. Output capacity for sodium silicate, used in the manufacture of catalyst, will be 600,000 lb. a day. It will be made by a new process developed by Cowles Chemical Co. of Cleveland. The process is designed for efficient manufacturing and a product of improved purity.

When Chester F. Hockley, now chairman of the board, took over direction of the old Davison Chemical Co. in 1933 the company, principally engaged in fertilizer manufacture, was in receivership. Instead of liquidating it, Hockley reorganized it, starting diversification into industrial chemicals.

Since the reorganization, sales have increased from $7 million to $50 million a year. The new Lake Charles

plant, according to President R. L. Hockley, is part of a current expansion that will cost more than $25 million.

New Furnaces Will Double Capacity of Carbide Plant

Calcium carbide and acetylene generated from it are now being produced in the new Calvert City, Ky., plant of National Carbide Co., a division of Air Reduction Co. Pipeline deliveries of acetylene are going to the neighboring plant of B. F. Goodrich Chemical Co. Initial product of this new Goodrich plant will be vinyl chloride monomer.

Mounting demand of the chemical industry for acetylene from calcium carbide led to the decision to double the original rated capacity of 142,500 tons of calcium carbide per year.

Construction of two additional furnaces has begun. This added capacity will be ready early in 1954.

Total cost of the plant, including the acetylene generating plant and related facilities, will exceed $17 million.

Electricity required to run the expanded plant will amount to 120,000 kw.—enough to meet the normal power requirements of cities the size of Columbus, Ohio, or San Antonio, Tex.

When the expansion of the plant is completed, calcium carbide will be shipped from Calvert City to Louisville, Ky., to supply acetylene to the neoprene plant of Du Pont. These shipments will supplement production at National Carbide's Louisville carbide plant.

The Calvert City plant site tract has been increased from 1,300 to 1,500 acres. Purpose of this tract is to make plant sites available to other chemical manufacturers who want to get acetylene via pipeline. The Goodrich plant is located on a site acquired from Air Reduction.

New Polyvinyl Chloride Producer for Ashtabula

Plans for expansion in chemicals, foam rubber and plastics have been approved by the board of directors of General Tire & Rubber Co. To get funds for the expansion, General will sell its stock in Mansfield Tire & Rubber Co.

A chemical plant will be built near Ashtabula, Ohio, at a cost of about $6

million, according to President W. O'Neil. It will include a pilot plant and a commercial polyvinyl chloride resin plant.

In addition, General will broaden its foam rubber operations, now at Logansport, Ind. The foam rubber operation is expected to be in full production by midsummer.

A rigid plastics division will be opened at Marion, Ind., where retooling has already started. First shipments of plastic products to be manufactured have already been completed through pilot-plant operations at General Tire's Wabash and Logansport plants.

Spencer Seeks Engineers For Polyethylene Plant

Spencer Chemical Co. will produce about 45 million pounds per year of polyethylene in a new $22 million plant to be built on a 400-acre site at Orange, Tex.

Polyethylene will be made by the process of Imperial Chemical Industries, Ltd., which Spencer will be licensed to use. Ethylene will come from Gulf Oil Corp.

When the plant starts operating in the spring of 1955, it will employ about 250 workers. Spencer will recruit chemical engineers and other technical men for top production and management jobs.

Cryolite: First recovery plant of its type is just getting into full operation at Longview, Wash., where Reynolds Metals Co. now recovers cryolite.

Caprolactam: Mathieson Chemical Corp. will build a plant at Morgantown, W. Va., to produce caprolactam. It will be used as a raw material by American Enka Corp. in the production of nylon fiber. American Enka has been licensed by Du Pont to produce nylon in the U. S. In a plant at Emmen, Holland, a foreign affiliate of American Enka has been making nylon from caprolactam.

Pickle Liquor: A new European process now being adapted by Blaw-Knox Co. of Pittsburgh, Pa., recovers waste pickle liquor in steel plants. The entire sulfate content of the waste pickle liquor is recovered as sulfuric acid that can be used again.

CONVENTION CALENDAR

American Leather Chemists Association, annual meeting, Netherland Plaza Hotel, Cincinnati, June 7-10.

Manufacturing Chemists' Association, joint meeting with SOCMA, Greenbrier Hotel, White Sulphur Springs, W. Va., June 11-13.

Synthetic Organic Chemical Manufacturers Association, joint meeting with MCA, Greenbrier Hotel, White Sulphur Springs, W. Va., June 11-13.

American Plant Food Council, annual meeting, The Homestead, Hot Springs, Va., June 11-14.

National Fertilizer Association, annual meeting, Greenbrier Hotel, White Sulphur Springs, W. Va., June 15-17.

American Society for Testing Materials, annual meeting, Chalfonte-Haddon Hall, Atlantic City, June 29-July 3.

American Pharmaceutical Association, Salt Lake City, August 16-22.

American Chemical Society, fall meeting, Conrad Hilton Hotel, Chicago, September 6-11.

American Institute of Chemical Engineers, Fairmont and Mark Hopkins Hotels, San Francisco, September 13-16.

National Petroleum Association, annual meeting, Traymore Hotel, Atlantic City, September 16-18.

American Association of Textile Chemists & Colorists, annual meeting, Conrad Hilton Hotel, Chicago, September 17-19.

American Coke & Coal Chemicals Institute, annual meeting, Greenbrier Hotel, White Sulphur Springs, W. Va., October 12-13.

Salesmen's Association of the American Chemical Industry, chemical sales clinic, Commodore Hotel, New York, October 19-20.

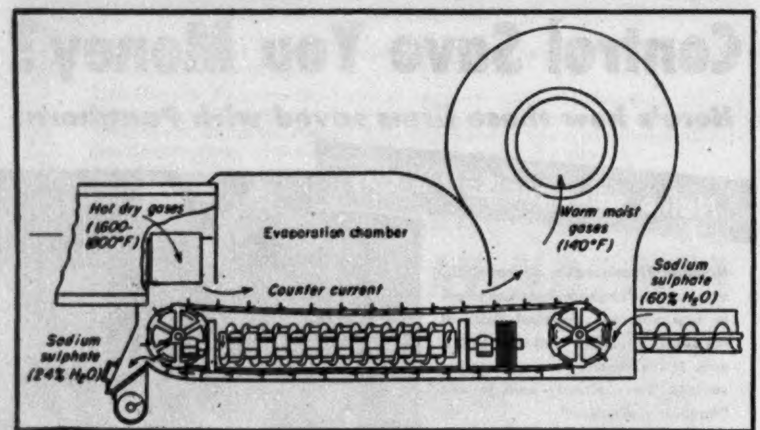
National Paint, Varnish & Lacquer Association, annual meeting, Chalfonte-Haddon Hall, Atlantic City, October 26-28.

Association of Consulting Chemists & Chemical Engineers, annual meeting, Belmont Plaza Hotel, New York, October 27.

American Petroleum Institute, annual meeting, Conrad Hilton Hotel and Palmer House, Chicago, November 9-12.

American Institute of Chemical Engineers, annual meeting, Jefferson Hotel, St. Louis, Mo., December 13-16.

Pro and Con



Pro: Holland Evaporator

Sir:

Your April issue of *Chemical Engineering* is a most outstanding piece of work.

The report on Evaporation by E. E. Lindley described all the types of evaporators used in general practice, but I found that he had entirely overlooked the Holland evaporator initially described in your magazine in 1951. . . .

A. A. Holland

Consulting Engineer
Pensacola, Fla.

► *The initial Holland evaporator (see cut) was described fully in our January 1951 issue (p. 106–107).*

This evaporator was designed by Consultant Holland to overcome the problems of dehydrating Glaubers salt at the Saskatchewan government's plant at Chaplin. It has since been modified and improved and now shows considerable promise of much wider application in the chemical process industries.—Ed.

300,000 Tons from Mexico

Sir:

I have carefully read your article on the Pan American Sulphur Co. on p. 128 of your January issue. The article is interesting but possibly somewhat optimistic.

As you indicate, Pan American will probably become a leading producer in Mexico. Pan American, however, is not the first Frasch sulphur plant to be built outside the United States because Mexican Gulf, perhaps fifteen miles away from Pan American's concessions, is scheduled to complete its plant by February or March of 1953.

You may be interested to know that I rate Mexico as second to the United States in sulphur production within two to three years.

Seymour Schwartz

S. Schwartz & Associates
Consulting Engineers
New York 6, N. Y.

► *Consultant Schwartz, a specialist on the sulphur industry and its processes, estimates that three big Mexican plants—Pan American, Mexican Gulf and Pemex—will be able to turn out some 300,000 tons of sulphur annually by 1955.—Ed.*

Pro: The Right Job

Sir:

I would appreciate two reprints of your fine article "Are You in the Right Job?" published in your November issue (p. 290).

I would like to place these in a file for my two children—now two and four years old—to be given them on entering high school and again on entering college.

C. W. Clift

Project Engineer
Vitro Corp.
New York 7, N. Y.

► *Says Editor Reeves, author of the article in our You & Your Job department: ". . . just about the nicest compliment that ever came my way."—Ed.*

Pro & Con: Science Policy

Sir:

I read your April editorial "How Can We Achieve a National Science Policy?" with deep interest. It touches upon one of the most important problems facing us today.

With the vast sums being spent for pure and applied research by our government and with these appropriations being parcelled out through hundreds of bureaus, divisions and agencies, there is no place where any coordination, review, analysis or evaluation of results takes place. Each agency is a "law unto itself." Nor is there any opportunity to coordinate government-supported research (both pure and applied) with that being conducted by our industries, colleges, universities and scientific institutions.

You point to the alarming amount of government-supported applied research and development that tends to crowd out basic research in our non-profit institutions. You mention the danger of pure research men being induced to leave our institutions for careers in "military or other government laboratories."

These tendencies need constant criticism to bring them forcibly to public attention. To this end a forum such as that proposed by Rep. Hinshaw in H. J. Res. 166, similar to the Parliamentary & Scientific Committee in Great Britain, would be highly desirable if it could function effectively.

Our parliamentary system and organization, however, are very different from that of Great Britain. Our Senators and Representatives are presently so overloaded that I question whether the suggested fourteen members would have time, energy or enthusiasm to give to a "scientific forum." Rep. Hinshaw, with his background of engineering experience, has a natural interest in scientific research. But how many members of the House and Senate have sufficient background in science or technology to induce them to give their time to such forums?

You dismiss the National Academy of Science and the National Research Council as possibilities, suggesting a new body with "more active participation on the part of industry and of our scientific and engineering societies." I tend to agree with you.

But is this not another indication of an American trait—start a "new"

organization? Possibly the first approach might be to throw this "forum" problem to the NRC and see if it could reorganize so as to carry out the desired industry, education and government cooperation. A tentative approach toward this is now being organized unofficially.

The National Science Foundation has been charged with formulating a "National Scientific Policy." This also authorizes the inter-agency transfer of funds appropriated for or allocated to basic research to NSF. In 1952 these inter-agency transfers amounted to only $104,420. It seems reasonable to suppose that bureau jealousies militate heavily against any large-scale integration save by Congressional or Presidential mandate.

Such transfers as did take place in fiscal 1952 were for the express purpose of studies leading toward a "National Scientific Policy." At the NAM Committee on Research luncheon on March 19, Alan T. Waterman of NSF spoke of these studies as being "under way" but said it was too early to give any results. Possibly the present drive for government economy may induce either Congress or the President to issue a mandate consolidating a major part of governmental basic scientific research expenditures under NSF.

Such a consolidation might well reduce the large "overhead" of bureau and Foundation expenses. Yet there are dangers in having too great consolidation of responsibilities. Were there only one government agency to which the research man with a prospective program of basic scientific studies could turn for support, it would have a serious drawback.

Every agency must be administered by human beings. All of us have natural "likes and dislikes." When dealing with uncertainties—such as all research proposals are—we tend to choose those which do and turn down those which do not strike a responsive chord. With speculative problems in pure research we can never hope to be prescient—only unbiased and open minded. Hence some degree of multiplicity of sources to which the research worker can apply for support is desirable and necessary.

J. W. BARKER

President
The Research Corp.
New York, N. Y.

► *Our April editorial calling for a sounder*

national science policy is stirring up serious comment and worthwhile suggestions from many quarters. We hope that many more of our readers will join in these discussions through our Pro & Con columns.—Ed.

Pro: Protective Coatings

Sir:

The articles and information given on Protective Coatings in your December issue (pp. 143-176) are informative and comprehensive. Congratulations to you, your staff and Mr. Tator. The chemical industry badly needed this type of factual information, and you have done a magnificent job.

Since we manufacture many highly corrosive chemicals, we know the cost of corrosion. As you know, Pennsalt has undertaken an extensive paint and coating evaluation program which is continuing. We believe that this particular phase of the chemical industry will change and grow rapidly as more intelligent and comprehensive studies are made, new products are made and new methods are developed. Therefore, we hope that you will report to the industry at regular intervals—possibly once a year.

We particularly like the method of classifying the chemical resistance of various type materials so that the class of service is considered.

In the Directory of Trade Names, we question the advisability of calling a range of thicknesses "mastics" since the word mastic has been used for many years to identify asphalt compositions. The word "bitumen" is also questioned since it normally refers to asphalts of bituminous (coal tar) origin, and most of the products listed under "Asphalt Bitumens" are actually of a petroleum or natural asphalt base.

We notice some errors in the Directory, probably due to misunderstanding of definitions. An example is Emulastic under the heading "Asphalt Bitumens." Emulastic is an asphalt-water emulsion used with concrete to enable feather edging; use as a lining for immersion service would be disastrous.

R. S. Mercer

Sales Engineer
Corrosion Engineering Products Department
Pennsylvania Salt Manufacturing Co.
Philadelphia, Pa.

▶ *We appreciate these comments on our December special report on Protective*

Coatings. This was the work of Consultant Kenneth Tator and Editor Morgan Hoover.

*And we'd like to list here a few Pennsalt products that were inadvertently omitted: Pennsalt NeoCoat is a Neoprene-type coating; NeoLine is a Neoprene-type mastic or lining; Thick-Coat has a chlorinated aliphatic hydrocarbon base and is not a chlorinated rubber-type coating.—*ED.

Con: Costs by Kilowatts

Sir:

The use of a parameter such as energy consumption in cost control as proposed in "Control Costs by Kilowatts" by D. E. Pierce (*Chemical Engineering*, January 1953) might be of value for statistical studies. But for routine plant cost control it is more desirable to relate standard costs to production.

It seems to be an unnecessary complication to determine the relationship between production rate and power consumption and then to make a further extension to the individual items of plant cost. Curves similar to those shown in the article can be prepared relating dollars, man-hours, or raw materials to the production. Also, our cost control program rests primarily in the hands of the process supervisors and foremen who are directly concerned with production rates and schedules. These men accept standard costs in relation to production but would distrust such an indirect attack as costs in terms of power which itself is subject to deviation and control as an item of cost.

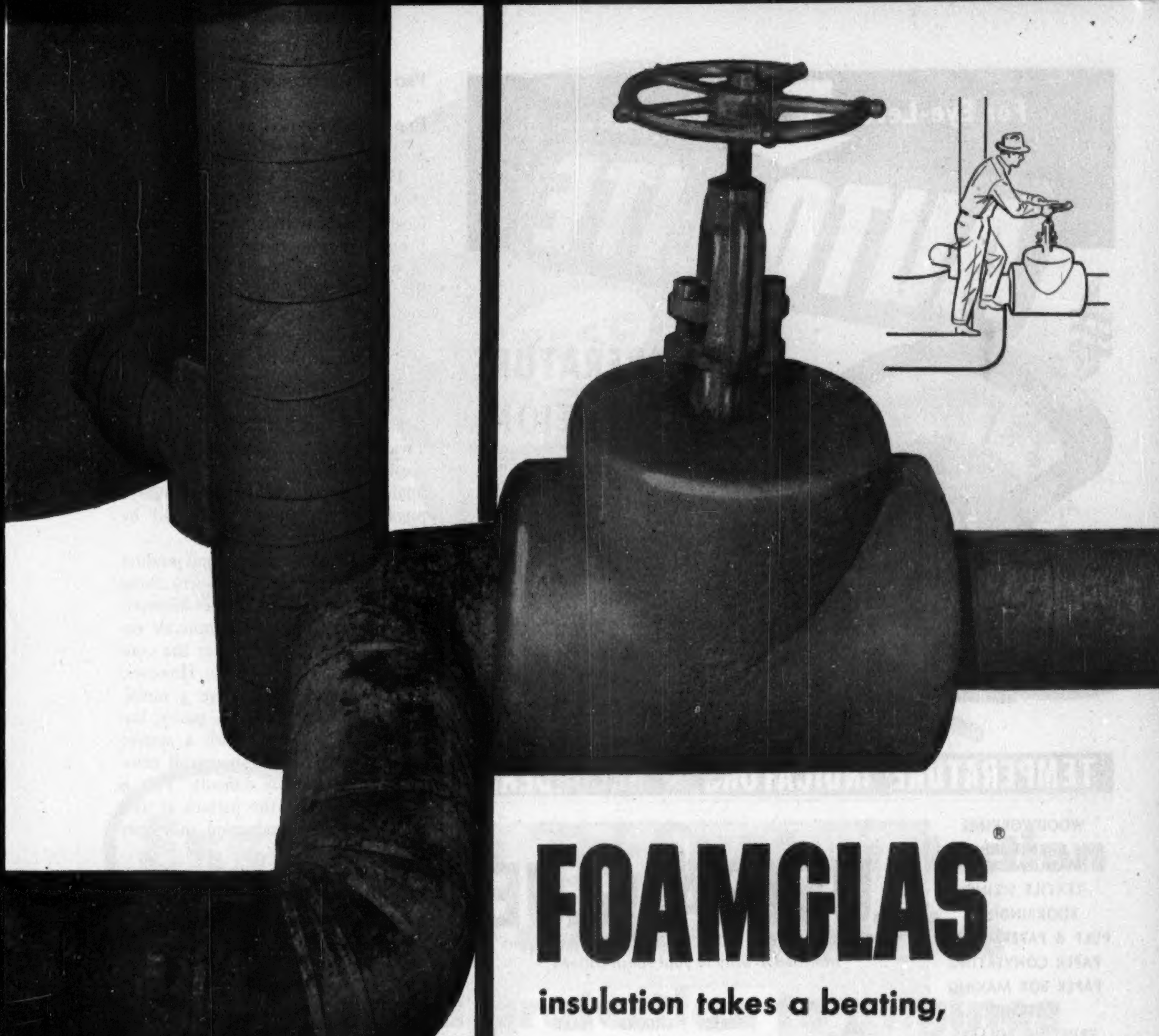
As is pointed out in the last paragraph of the article, the method is based on past performance. In order to maintain reasonable and up-to-date targets for current operations, we find it necessary and desirable to review our standards each six months and to revise them as frequently as necessary. Any system based on past history will give standards which are obsolete before they are prepared.

It must also be pointed out that ±10 percent is not a sufficient accuracy for our purposes. We expect performance to be within 5 percent of standard in most cases, and for raw materials an accuracy of ±0.5 percent is frequently expected.

C. P. STANFORD

Chemical Engineer
Niagara Falls, N. Y.

► *For Author Pierce's reply, see the letter that follows.—*ED.



Pro: Costs by Kilowatts

Sir:

The comments by Mr. C. P. Stanford on my article "How to Control Costs by Kilowatts" are interesting. From the point of view of the cost of individual products to which Mr. Stanford refers, I am entirely in agreement with him.

The real advantage of the system of "Cost Control by Kilowatts" is to give an over-all picture of plant performance, comparing current operations with previous performance over a wide range of activity, and providing means of forecasting both labor and financial requirements quickly with a precision that can be calculated by the usual statistical methods.

For plants making only one product (or a relatively small number) there may be no reason to use kilowatt-hours as a common denominator except for maintenance or for the consumption of "energies." However, most chemical plants have a multiplicity of products (solids, pastes, liquids and gases) for which a system of weighting to get an overall comparison is extremely difficult. This is always true when the pattern as well as the rates of production may vary considerably.

As to the precision to be expected, the use of a zone shaded 10 percent above and below the curve is a matter of convenience for quick visual estimation of variations of data. Normal random variations are usually within ±5 percent of the curves so that greater deviations are clearly evident and show the need for investigation.

DAVID E. PIERCE
Chief Engineer
General Aniline & Film Corp.
New York, N. Y.

Con: Not Being Listed

Sir:

On page 114 in the February issue of *Chemical Engineering* appears a tabulation of chemical engineering student enrollment for 1952-53. On this list the University of Cincinnati is not designated as being accredited by the AIChE and ECPD in chemical engineering.

For your information the University of Cincinnati's curriculum in chemical engineering was accredited on the first list issued by the AIChE

Esso gives *Tri-Sure* protection to the oil that helps give year-round protection to engines

ESSO'S UNIFLO MOTOR OIL—a new concept in lubrication—changes so little in viscosity that it meets four SAE classifications, functions efficiently at extremely low and high temperatures, and helps keep automotive engines at top performance.

To protect this new year-round premium oil—to assure the *delivery* of a pure product that gives peak performance—Esso uses Tri-Sure* Closures.

Esso uses Tri-Sure Closures for the same reasons that shippers all over the world insist on *Tri-Sure:* (1) the Tri-Sure *Flange* is integrally assembled with the drumstock; (2) the Tri-Sure *Plug* fits securely into the flange; (3) the Tri-Sure *Seal* forms a leak-proof covering which cannot be removed unless it is deliberately destroyed.

This is the protection you can *depend* on—no matter how far your drums are shipped. And this is the protection that *proves* to your customers that you are safeguarding their interests.

Play safe with every drum shipment by specifying "Tri-Sure Closures" on every drum order.

Tri-Sure

Reg. U. S. Pat. Off.

CLOSURES

*The "Tri-Sure" Trademark is a mark of reliability backed by over 30 years serving industry. It tells your customers that genuine Tri-Sure Flanges (inserted with genuine Tri-Sure dies), Plugs and Seals have been used.

AMERICAN FLANGE & MANUFACTURING CO. INC., 30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.

Tri-Sure Products Limited, St. Catharines, Ontario, Canada

and has been continuously on that list, as well as the ECPD list, ever since.

WILLIAM LICHT
Professor and Acting Head
Department of Chemical Engineering
University of Cincinnati
Cincinnati, Ohio

▶ *We regret our slip and the injustice done to the excellent chemical engineering department at Cincinnati.—ED.*

We Bait Ourselves

Sir:

I enjoyed no end the article "How to Write Poor Letters" in your January issue. . . .

"I'm a bit disturbed, though, at the thought of the potential customers' "baited breath." How would a good martini do for bait?

WILLIAM F. TALBOT
Plastics Products Div.
Rubberset Co.
Salisbury, Md.

▶ *Yes, we sure baited ourselves—and swallowed the hook, too! The embarrassment is all ours, the amusement that of the 73 sharp-eyed readers who refused either to be baited or bated.—ED.*

Pro: What's Happening . . .

Sir:

I've enjoyed your new department "What's Happening in Chemical Engineering" since you began it early this year. It is now one of my favorite sections of *Chemical Engineering* and one that I always read first.

The reason, as well as I can figure it out, is that it gives me a quick, accurate and rounded-out picture of what others are doing. But sometimes I wish you'd give more details on some of the developments. . . .

JAMES Y. HARDIN
Chemical Engineer
Wilmington, Del.

▶ *Reader Hardin puts his finger on one of our guiding principles for "What's Happening in Chemical Engineering"—"A quick, accurate and rounded-out picture" of significant developments.*

Yet he calls for "more details"—the very thing that would throw these news featurettes out of the quick-reading category that so many of our subscribers have been asking for and like. Our objective in "What's Happening" is to report—and more important—to interpret major developments rather than to publish details that would interest relatively few people outside the immediate field.—ED.

PRO AND CON, *cont.* . .

Con: Cathodic Protection

Sir:

I would appreciate your publishing the following correction to my article "Cathodic Protection Can Save Chemical Process Equipment," which appeared in the May, 1953 issue of *Chemical Engineering*. On p. 197, the table should be as follows:

Local Action Current Equivalent for Iron Apparent

Corrosion Rate In per Yr.	Equiv. Current Density Ma. per Sq. Ft.
0.001	2
0.01	20
0.1	200
0.25	500
0.50	1,000

Note that each value under equivalent current density should have been multiplied by 2.5.

L. P. SUDRABIN

Research Director
Electro Rustproofing Corp.
Belleville, N. J.

Pro: Executive Development

Sir:

The article appearing in the February issue of *Chemical Engineering* (p. 228) on the subject of "Why All the Fuss About Executive Development" is one of the best and most informative treatments of this subject that I have ever seen.

We are quite active in the area of management development and are highly interested in having had an opportunity to review what you edited for your publication.

I do not doubt that you have had other comments from other readers on your excellent paper and I just wonder if there are any plans to have such material reprinted. . . .

D. C. MOORE

Assistant Director
Personnel & Industrial Relations Dept.
Leeds & Northrup Co.
Philadelphia, Pa.

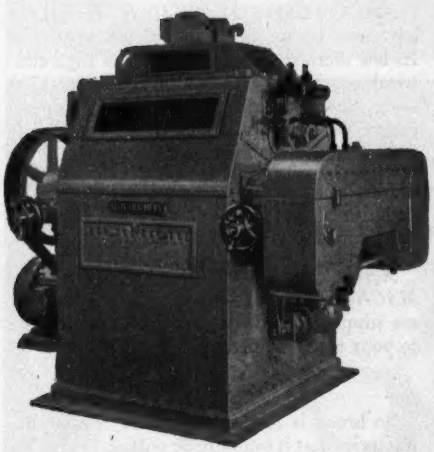
▶ *We will prepare reprints of our You & Your Job department if enough of our readers ask for them. What are your wishes?*—ED.

We welcome pertinent, informative letters from our readers everywhere. Address the Editor, *Chemical Engineering*, 330 West 42nd St., New York 36, N. Y.

ROLLS LAST LONGER in the Sanitary AIRSET ROLLER MILL

Circle-Chill rolls, smooth or corrugated, are also available for all Allis-Chalmers roller mills and other makes as well.

A clearly defined, uniform chill depth in Circle-Chill rolls provides maximum wear



The Extra Wear built into *Circle-Chill* rolls gives you a bonus of many additional months of profitable milling.

The toughness of the *Circle-Chill* roll is the result of a recently developed centrifugal casting technique. A wear-resistant, white iron shell is bonded to a softer gray iron core. Centrifugal casting makes possible a longer wearing milling surface with no soft gray iron permeation.

OTHER FACTORS IN LONGER ROLLER LIFE

In the *AirSet* roller mill there is no uneven roller wear. Rolls wear evenly because a high speed vibrating type feeder distributes stock uniformly over rolling surfaces. Air from a single source maintains equal pressure on both ends of rolls. When feed stops, rolls open automatically to prevent destructive metal-to-metal contact. Get complete facts from your nearby A-C sales office or write Allis-Chalmers, Milwaukee 1, Wisconsin, for Bulletin 06B7218.

AirSet and *Circle-Chill* are Allis-Chalmers trademarks.

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A-C ALLIS-CHALMERS

A-3979

Fill your chemical processing ℞ with Norton SPECIAL ℞efractories engineered to your needs

To improve chemical processes or increase yields, get your answer from Norton.

No *one* refractory can be the solution to all your problems. But Norton ℞ service will help you get the composition best suited to your particular purpose.

In almost every field of chemical processing, Norton Refractories are making definite contributions — improving methods and cutting costs. This is true in catalyst supports for the manufacture of phthalic anhydride, for reforming natural gas and production of "atmosphere gas" — electric furnace shapes . . . porous mediums, for filtration, diffusion and aeration.

To get your ℞ in catalyst supports

Norton makes catalyst supports having *controlled* structure. Thus the ℞ for rings and pellets can range from medium porosity to high porosity — for spheres from medium porosity with rough exterior for coating with a catalyst, to high porosity with a network of open pores throughout and rough exterior designed for impregnating with catalyst. Spheres are made in diameters ¼" to 1". Rings supplied from 3/32" I.D., 3/16" long, 7/32" O.D. to ½" I.D., 1" long, 1" O.D. Pellets from ⅛" x ⅛" to ½" x ½". Catalyst supports are just an example of ℞ engineering.

The "Basic 4" for your ℞

According to the requirement your ℞ is for ALUNDUM*, CRYSTOLON*, MAGNORITE*, or FUSED STABILIZED ZIRCONIA, each with its own particular characteristics. All are chemically stable . . . all are highly refractory, resistant to abrasion and have extra long life. Here are just a few of their uses in many fields.

Norton ALUNDUM catalyst supports in the manufacture of phthalic anhydride, production of "atmosphere gas" and in reforming natural gas.

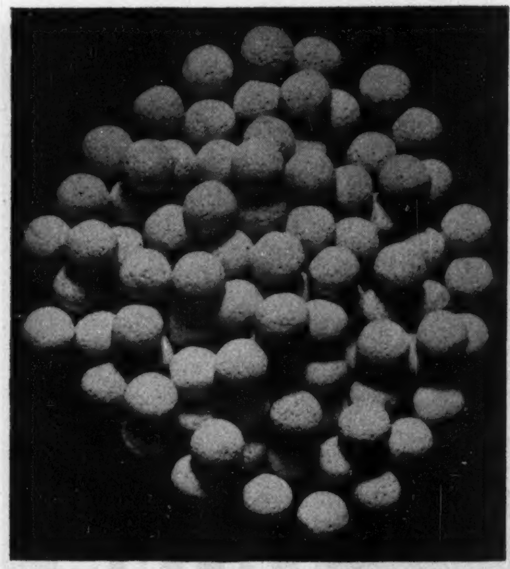
Norton FUSED STABILIZED ZIRCONIA has stood up under 4700°F in gas synthesis. Its low thermal conductivity and its high electrical conductivity at elevated temperatures make it useful for many special chemical processes. No other refractory is so chemically stable under high temperature.

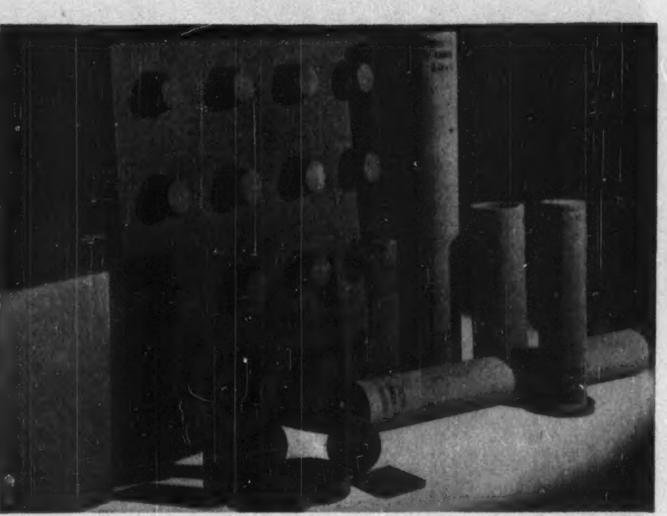
Norton ALUNDUM porous mediums with "controlled permeability" are ideal for filtration, diffusion or aeration.

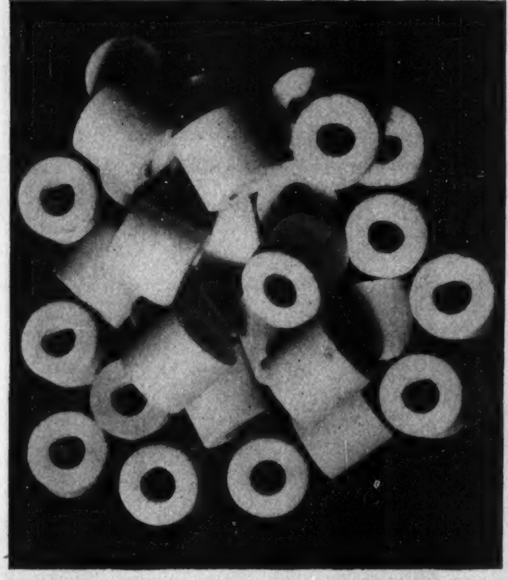
Norton ALUNDUM, CRYSTOLON and MAGNORITE mixtures for reaction furnaces are supplied in a variety of shapes engineered to your exact requirements.

Find out more

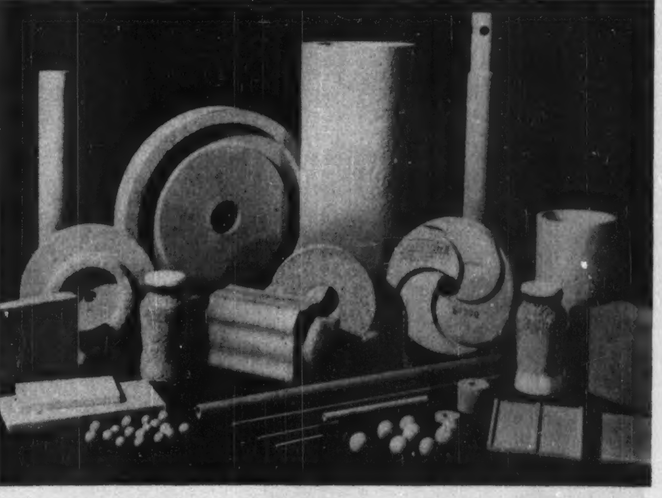
So broad is Norton's range of Special Refractories that it can only be outlined here. We believe that it will pay you to make Norton Refractory Research your partner in solving your problems. For quick action, just contact your Norton Refractories Representative or write NORTON COMPANY, 505 New Bond St., Worcester 6, Mass.



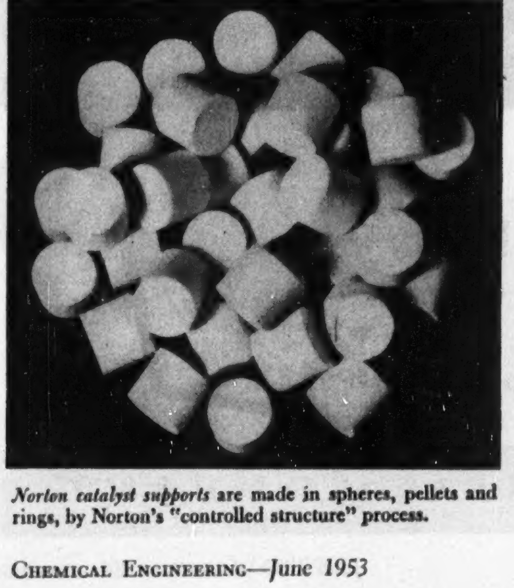




Norton catalyst supports are made in spheres, pellets and rings, by Norton's "controlled structure" process.



Norton ALUNDUM porous mediums come in plates, tubes, discs and diaphragms to fit your exact requirements.

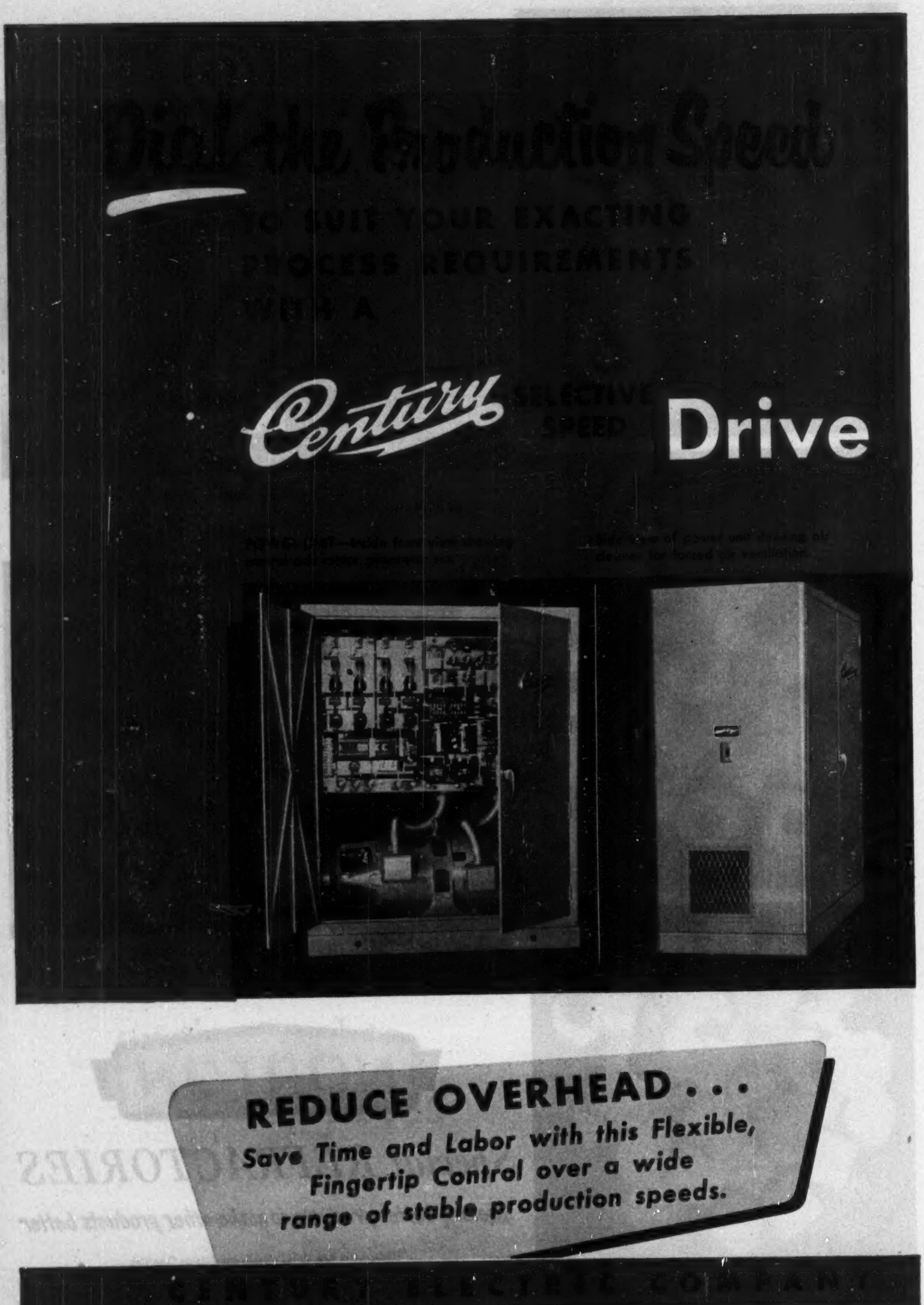


Norton refractory shapes for reaction furnaces come in bricks, plates, tubes and blocks of ALUNDUM, CRYSTOLON, MAGNORITE and FUSED STABILIZED ZIRCONIA.

Special REFRACTORIES

Making better products to make other products better

*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries


Dial the Production Speed
TO SUIT YOUR EXACTING
PROCESS REQUIREMENTS
WITH A
Century
SELECTIVE
SPEED
Drive
REDUCE OVERHEAD . . .
Save Time and Labor with this Flexible,
Fingertip Control over a wide
range of stable production speeds.
CENTURY ELECTRIC COMPANY

for your information...

brief summaries of helpful product news

PENTACHLOROPHENOL and Its Sodium Salt Outstanding Industrial Preservatives

Pentachlorophenol, Technical

Molecular Wt.: 266.35

Formula: OH

Specifications: Dark, grayish flakes; crystallizing point 174.0° C. min.; alkali insoluble material 1.0% max.; assay 96.0% min.; pine oil solution NPA 5.5 max.

Sodium Pentachlorophenate, Technical

Molecular Wt.: 288.36

Formula: ONa

Specifications: Light tan powder, pellets or briquettes. Assay 88.0% min. Free alkali (as NaOH) 0.5-0.9%.

Two of the most versatile and widely used chlorinated phenols manufactured by Monsanto are pentachlorophenol, technical, and sodium pentachlorophenate, technical. The sodium salt bears the trade name, Santobrite.*

As a wood preservative, penta is outstanding. It is being used by railroads, utilities, private industry, and in farm and home construction, to protect wood against rot and insect attack.

Railroads cut maintenance and repair costs by using penta to preserve car decking, switch-ties,

platform decking and other installations. In hospitals and public buildings, penta-treated lumber is used for sills, subflooring and roof plank.

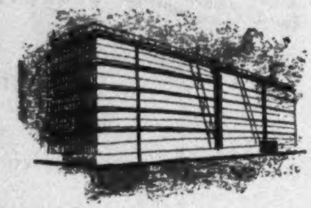
Penta is applied most effectively at commercial treating plants by an economical pressure process. The preservative, in petroleum oil, is forced deep into the cells of the wood. As rain or ground water will not wash out the penta, service life of the wood is extended three to five times over that of untreated wood.

Plywood adhesives of the cold-press type are treated with penta to make them resistant to mold and bacterial action, under specifications of the Douglas Fir Plywood Association.

Weed killing is another application of penta. It is a nonselective herbicide for eliminating plant growth on roadsides, rights of way, etc. It is also a desiccant for preharvest drying of crops such as cotton.

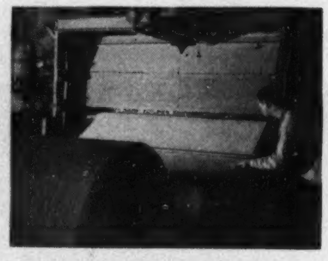
For a booklet on Penta as a wood preservative, mail the coupon.

Santobrite Proved Effective Against Microorganisms



Monsanto Santobrite, the sodium salt of penta, is also distinguished by its versatility and service to diverse industries.

In cooling systems Santobrite is a highly effective means of controlling slime and algae which cause serious fouling of water passages and heat transfer surfaces if allowed to grow unchecked.



In the pulp and paper industry Santobrite provides an efficient way of controlling microorganisms which cause slime spots, blinded wires, plugged felts, obstructed stock and water lines.

Hardwood and insulating board, when treated with Santobrite or penta, will resist rot, mold and insect attack. Mold is generally a problem when insulating board is used in the decoration of basement rooms or rathskellers, or in any hot, moist area.

Other applications for Santobrite include its use in killing microorganisms which cause deterioration in adhesives, leather, casein and oil paints and rubber latex.

Interesting experiments with Santobrite have been conducted by Army, Navy and Public Health officials in a campaign to eradicate certain species of snails. In China, Egypt, Africa, Brazil and other countries, snails act as intermediate hosts for schistosomes,

which cause the fatal disease, schistosomiasis, in humans. Santobrite has proved to be an efficient chemical for controlling the snails.

Santobrite Sprays Used For Effective Weed Control

Santobrite is now being used for pre-emergence weed control.

Its use in this application has several advantages. It is economical and can be formulated as a dry mix or water concentrate. Monsanto's sodium pentachlorophenate is not a hormone-type weed killer and there is little danger from spray drift.

Moreover, Santobrite will provide effective weed control during periods of high ground moisture when mechanical methods are impractical or impossible.

For more information, send in the coupon.

Monsanto Offers Booklet For Fertilizer Manufacturers

A new booklet of interest to the fertilizer industry has been recently published by Monsanto.

An eight-page brochure entitled, "Questions and Answers on the Use of Santomerse* in Mixed Goods Fertilizers," it gives clear, concise information on how Santomerse can reduce caking in bin and bag and cut curing time.

For your copy send in the coupon today.

Santomerse Cuts Mold Count in Fruit Washing

Strawberries, among the most susceptible of fruits to mold, have now been effectively washed using a technique developed jointly by researchers of the University of Tennessee and Monsanto Chemical Company.

Mold count reductions ranging up to more than fifty per cent—a figure which may mean the difference between profit or loss to the grower and processor—have been obtained by the new method.

Since strawberries are among the most difficult of fruits to clean and process due to the rough texture of the surface, it is assumed that the new washing technique will be equally effective in lowering mold count in other fruits susceptible to the problem.

The results were obtained by the addition of small amounts of Monsanto's Santomerse D, or Sterox*CD detergents to the wash water. Both gave good detergency results, and the Santomerse solution had the added advantage of imparting slight bactericidal activity to the wash water.

The tests were carried out initially in the laboratory. During the last growing season, the work was carried on in regular processing lines with a variety of conventional washing equipment.

Controlled Leavening, Long Shelf Life with Monsanto SAPP

As prepared mixes increase their sales in the baking field, leavening becomes more important than ever before. To sell such mixes the manufacturer must be certain of a product which has a long shelf life and uniform leavening action.

Monsanto SAPP (sodium acid pyrophosphate) has already proved its ability by actual use in a wide number of prepared cake mixes. Manufacturers find that they obtain several advantages.

Monsanto SAPP gives a uniform rate of reaction with a carefully controlled release of gas. It also possesses a long shelf life and gives good volume and texture in the final product.

For more information on how Monsanto SAPP can help in your cake and doughnut mixes, use the coupon on this page.

New Compounds Safer, Less Costly to Ship Than Gaseous Phosgene

Two new Monsanto intermediates, Carbamyl Chloride and Isopropyl Chlorocarbonate, are designed for basic chemical manufacturers who need phosgene intermediates but wish to avoid the inconvenience and expense of handling gaseous phosgene directly.

In-plant handling and storage problems have been minimized by means of new shipping techniques that are safe yet economical.

Call the Monsanto office near you for complete information. Meanwhile, check the coupon below for descriptive bulletin.

*Reg. U. S. Pat. Off.

MONSANTO CHEMICAL COMPANY 4/53
1703 South Second Street, St. Louis 4, Missouri

Please send:

- ☐ Penta Answer Booklet
- ☐ Bulletin, Santobrite for pre-emergence weed control
- ☐ Bulletin O-23, Santobrite (general)
- ☐ SAPP
- ☐ Santomerse for Fruit Washing
- ☐ Questions and Answers on the Use of Santomerse in Mixed Goods Fertilizers
- ☐ Phosgene Compounds, P-150

Name...Title...............

Company...

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City...Zone.....State.........

JUNE 1953 Chemical Engineering

HEAT TECHNOLOGY

This is our first over-all report on heat technology since April 1932. In the intervening years there have been reports on several parts of the problem, such as heat transfer, fuels and energy supply, steam generation, and atomic power. But here you will find 11 articles and a chart which cover the subject from fuels, combustion, electric heat and refrigeration, through furnaces and construction materials, on to heat transfer media, theory, and latest equipment.

CHEMICAL ENGINEERING REPORT—JUNE 1953

Introduction

Heat Technology is a broad term conveying the idea of thermal energy in all its aspects in process industries. It does not mean heat transfer alone, nor temperature level alone, nor energy supply or utilization. Rather it means—and this is how it has been used here—(1) the **production** or removal of energy in the form of heat; (2) the **containment** of heat, or its exclusion in low-temperature processes; (3) the **transport** of heat energy from source to process by the use of heat transfer media; (4) the **transfer** of heat by radiation or convection, or by conduction through a heat-transfer surface; and finally (5) the **application** of heat energy for processing purposes.

The last of these is not covered in this 60-page report, but considerable information on the **temperature level** of chemical and other industrial processes has been incorporated in the chart which follows page 176.

SCHEME OF REPORT

In addition to the introduction, this report consists of an integrated group of 11 articles and a folded chart, the latter dramatizing the importance of temperature in heat technology. The first four, of the five main aspects of heat technology outlined above, have been broken down into individual articles as follows:

Thermal Spectrum Chart

Heat and Cold Production

1. Fuels
2. Combustion
3. Electric heat
4. Refrigeration

Heat Containment

5. Furnaces
6. High- and low-temperature metals
7. Refractories
8. Insulation

Heat Transport

9. Heat-transfer media

Heat Transfer

10. Heat-transfer theory
11. Heat-transfer equipment

FOLDED CHART

Temperature is not the be-all and end-all of heat technology, but it is the prime criterion in determining how thermal energy will flow. It usually determines what methods must be used in producing heat and cold, as well as how these will be transported and transferred. Temperature is one measure of the energy relations between various parts of a process—often the most important one. Therefore, the folded chart numbered pages 177-184* dramatizes the idea of a "Thermal Spectrum of Heat Technology."

The concept of a thermal spectrum is not strictly scientific in the sense that physicists refer to the electromagnetic spectrum, or the small portion of it which is the visible spectrum. But it does convey the idea of a temperature range from absolute zero to the highest we have at our command. The color strip featured at the top provides this effect, but again does so unscientifically, since it exaggerates the true color scale of temperatures, and introduces blue for cold, which does not exist in an actual color scale of temperatures ranging from black through red, orange and yellow, to white.

Main purpose of the chart, therefore, is to show visually where a large number of processes and other significant phenomena fit into the temperature picture, and through what ranges construction material are suitable. It should be noted particularly that data

* Note: Post Office rules require giving this eight-page chart eight actual page numbers, although only one side and only four of its pages are printed.

plotted on the chart are approximate only, and that conditions of use sometimes may alter the temperatures quite widely. In general, the cold production (refrigeration) methods shown indicate the useful temperature ranges. The heat production methods indicate mainly the top temperatures attained under various conditions, rather than possible process temperatures. The latter would require allowing for an uncertain amount of temperature drop. Data for the combustion processes are the best available measured temperatures, not the theoretical maximums. However, temperature measurements at the high end are variable, and reported temperature data often differ by 100 degrees or more. The same applies to high melting points.

Data for metals, refractories and insulation again are variable, but in the main are conservative. Service conditions may affect top temperature limits profoundly, so that the plots should be considered as indicative rather than definitive. In the case of process temperatures, a range usually indicates that a critical step may fall anywhere within that range, although a few of the short ranges shown mean that the process operates through that range.

CONTENTS—HEAT TECHNOLOGY REPORT

HEAT TECHNOLOGY TRENDS

Summarizing the main trends shown by the 11 articles which follow:

Fuels—Coal has taken a bad beating in recent years as its price has risen while oil and gas were becoming more available. It does, however, remain our mainstay for the future. Even then, there are those who expect nuclear energy eventually to become more important than coal, relegating the latter largely to the status of a raw material for fuel gas, liquid fuel and synthetic chemicals. Meanwhile, natural gas, the shortest lived of any of our potential fuels, continues to expand its markets in non-producing areas via the ever-extending pipelines.

Combustion—As combustion becomes better understood, present firing methods improve and new methods appear over the horizon. Although most of the development is taking place in jet-engine and rocket work, this inevitably will yield dividends affecting industrial processes. For example, chemical and petroleum people are already interested in combustion devices similar to those used in jet engines. In Germany the principle of the pulse-jet used in the V-1 buzz-bomb is being applied experimentally to coal gasification.

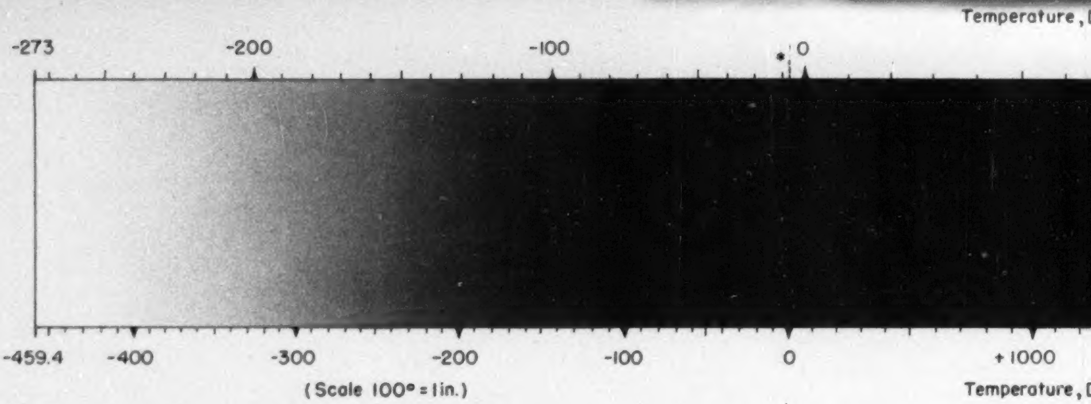
Electric Heat—More and more heating in process work is electrical. Where the dramatic heating jobs are those at high temperatures, using arcs and high-temperature resistors, the aggregate consumption of power in relatively low-temperature heating via the sheathed strip heater is actually much larger. Some of the newer methods, such as infra-red and dielectric, have not made as big an impact as was at one time expected, but both have developed well defined uses.

Refrigeration — Low - temperature processes have trended still lower in late years, especially among gas separation processes. Refrigeration units have grown larger, new refrigerants have emerged, and improved compression equipment has evolved widely.

Furnaces—As the means of bringing together the source of heat and the material being heated, the furnace is often a critical process component. The continuous tubular heater is supplanting batch-fired stills and kettles of earlier days, with keen competition between the horizontal and vertical types. In many processes today, the material being heated is an intermediate, transporting heat to the process.

Metals, Refractories, Insulation—Though the construction materials dealt with in this report are not the only ones for process equipment, metals—plus refractories and insulation—cover the great preponderance of equipment needs. The temperature limits are being actively expanded both ways, toward high and toward low. Most of the high-temperature job is going to the chrome and chrome-nickel steels, with extreme low temperatures serviced by the latter group, and by some of the non-ferrous metals, notably aluminum and copper. Refractories are moving ever higher, with increasing interest in pure oxides, nitrides and carbides for extreme conditions. Insulating refractories and insulations are pushing the extremes, with the ultimate probably not yet in sight at the high end. Insulations are being selected more judiciously, and they are

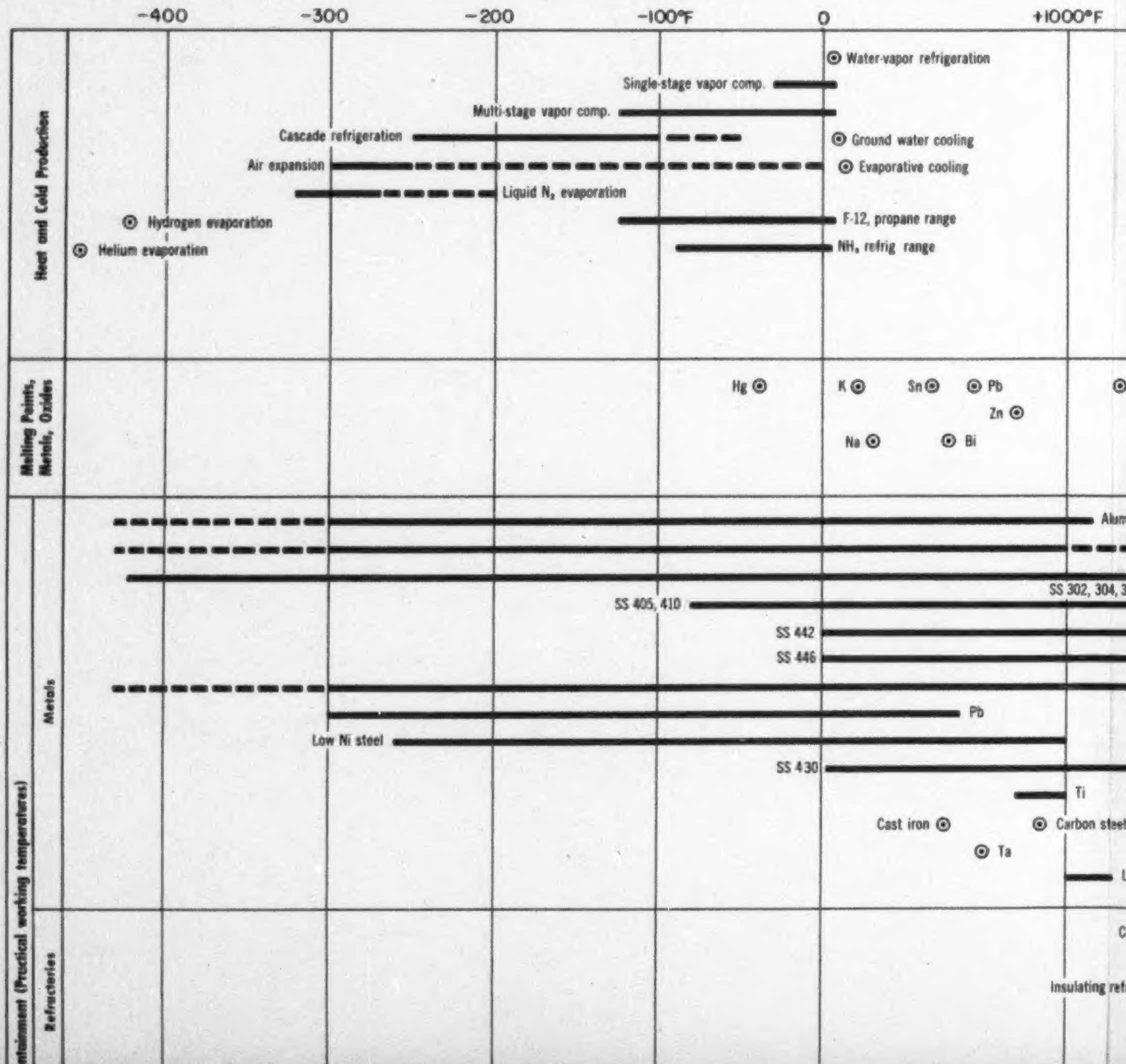
(Continued on page 185)

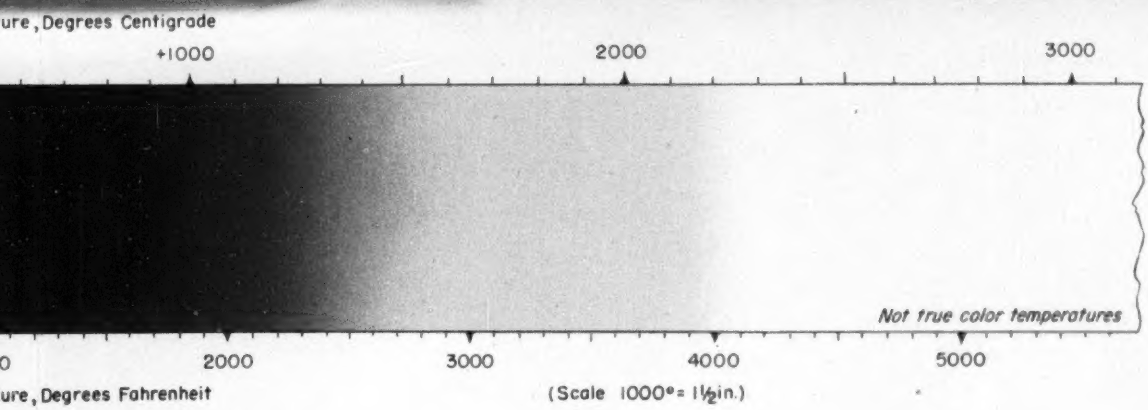


The Thermal Spectrum

Chemical Engineering, June 1953, pages 177 to 184

Shown below are some 200 "bits" of temperature data on (1) production of heat and cold; (2) heat containment by metals, refractories and insulation; (3) heat transfer media; and (4) typical process temperatures. It should be understood that these temperature points and ranges are approximate only and may vary with conditions of use. For example, the high limits for metals are for air contact, not considering creep. Refractory use limits can vary





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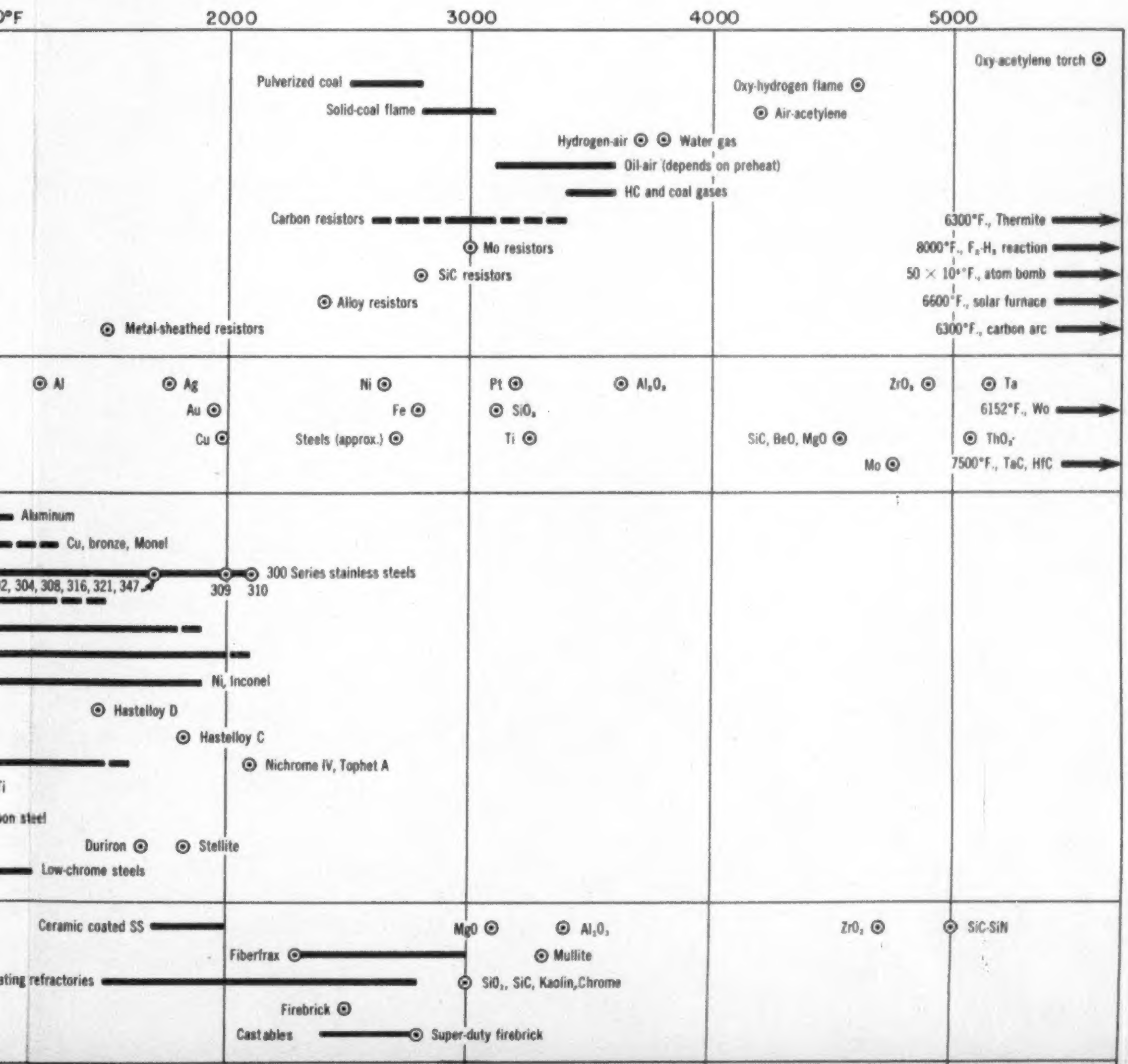
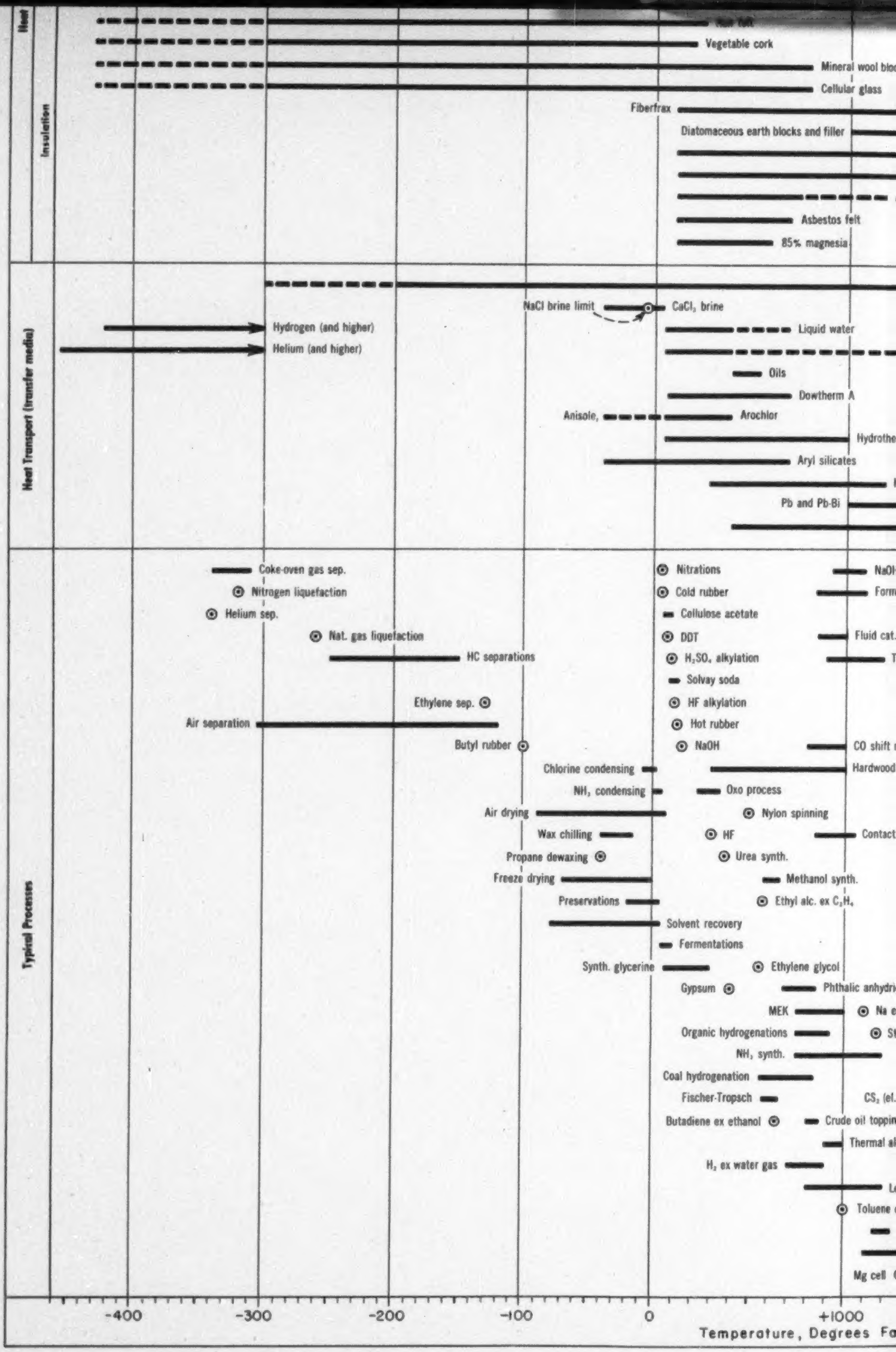
considerably with type of use. Process temperatures, though typical, are quite variable. Flame temperatures are actual, not theoretical, with minimum excess air. Reported values also vary quite widely.

*To allow space for showing low temperature phenomena, temperature scales are expanded 6⅔ times below 0°F. or −17.8°C. (dotted line), explaining the apparent interruption in the °C. scale.





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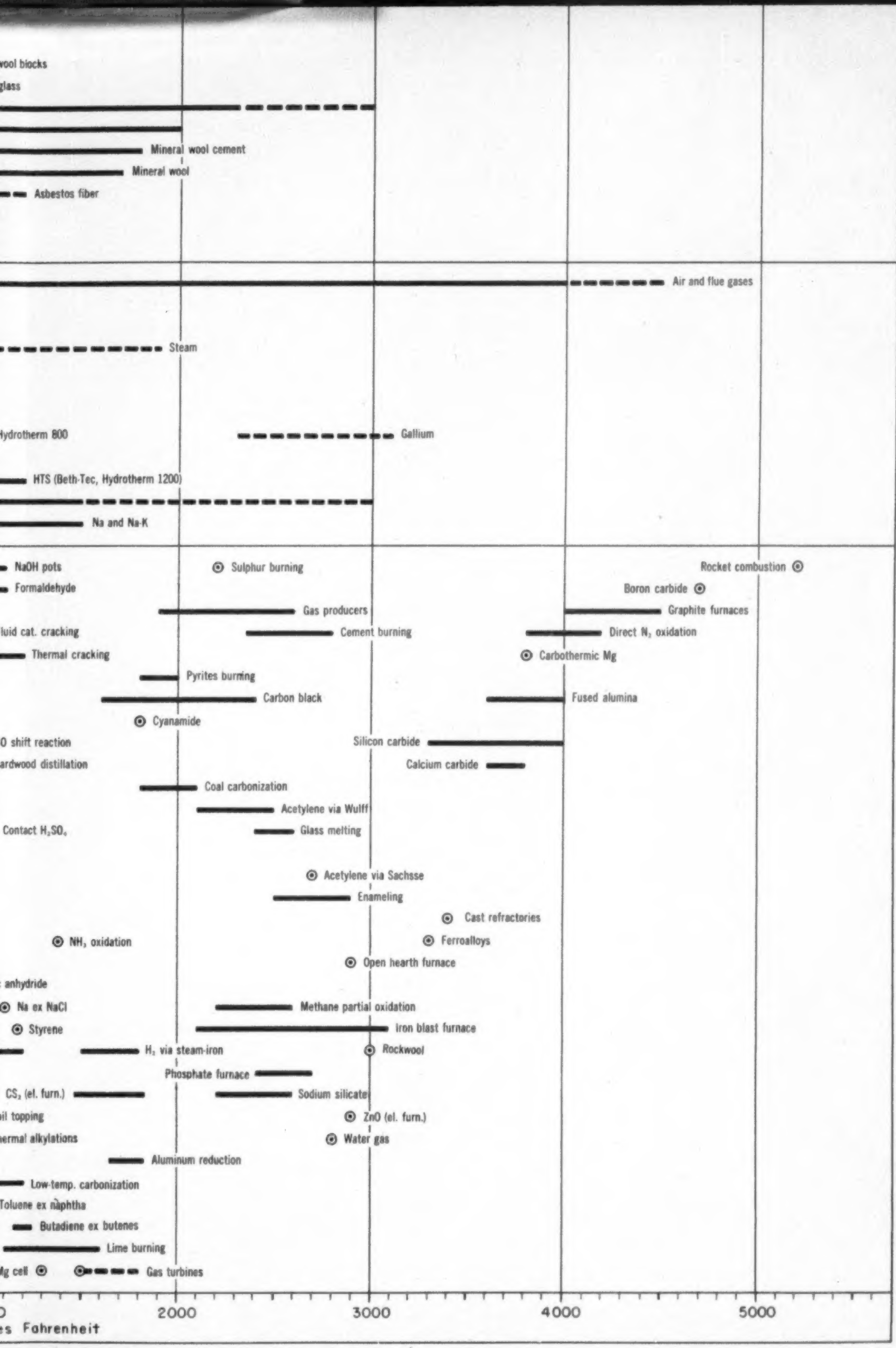

vool blocks
glass
Mineral wool cement
Mineral wool
Asbestos fiber
Air and flue gases
Steam
Hydrotherm 800
Gallium
HTS (Beth-Tec, Hydrotherm 1200)
Na and Na-K
NaOH pots
Sulphur burning
Rocket combustion
Formaldehyde
Boron carbide
Gas producers
Graphite furnaces
luid cat. cracking
Cement burning
Direct N_2 oxidation
Thermal cracking
Carbothermic Mg
Pyrites burning
Carbon black
Fused alumina
Cyanamide
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Calcium carbide
Coal carbonization
Acetylene via Wulff
Contact H_2SO_4
Glass melting
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Enameling
Cast refractories
NH_3 oxidation
Ferroalloys
Open hearth furnace
anhydride
Na ex NaCl
Methane partial oxidation
Styrene
Iron blast furnace
H_2 via steam-iron
Rockwool
Phosphate furnace
CS_2 (el. furn.)
Sodium silicate
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ZnO (el. furn.)
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Water gas
Aluminum reduction
Low-temp. carbonization
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Butadiene ex butenes
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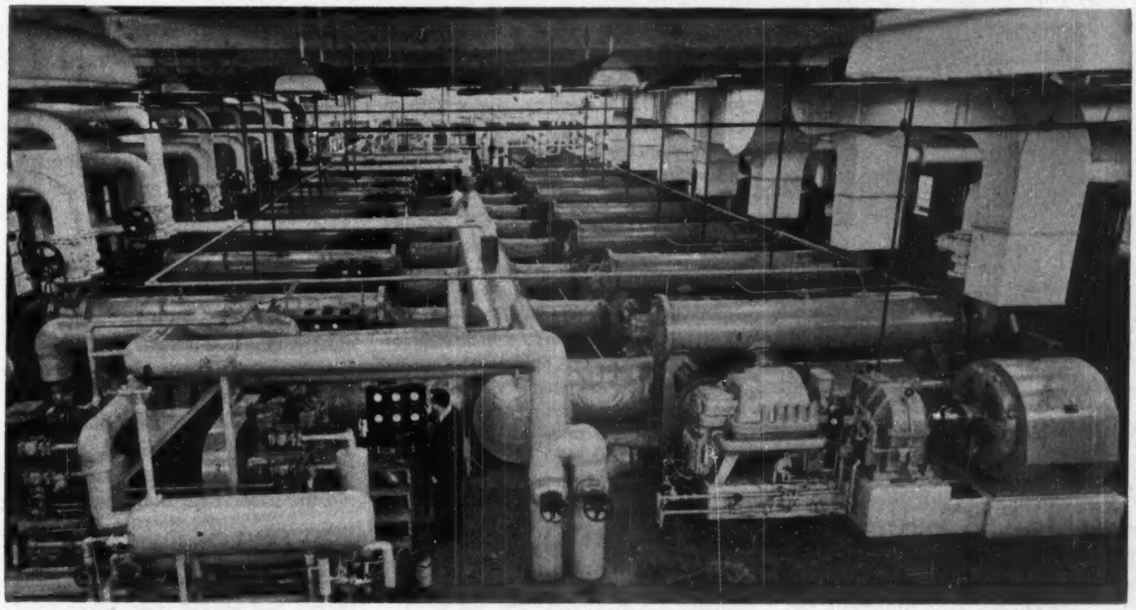
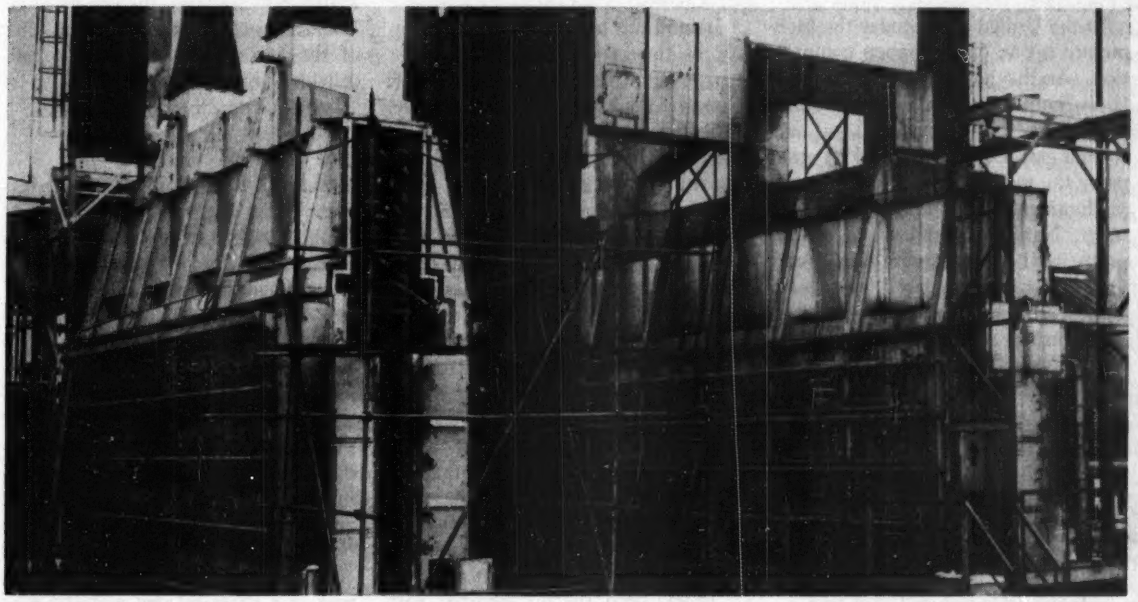


FROM LOW TEMPERATURES still below those reached by this 15,000-ton NACA installation of Carrier refrigeration units . . .



TO HIGH TEMPERATURES even above those in these radiant furnaces at Phillips Petroleum, is the range of heat technology.

being better protected from moisture. Reflective insulation is due for greater regard.

Heat Transport—Relatively few heat-transfer media are in extensive use, other than air and flue gases, steam and water. However, stable organics have pushed the low-pressure heat-transfer range toward higher temperatures, salt mixtures have come into wider use for processes up to 1,200 deg., and low-melting metals and their eutectics have entered the research picture actively, especially in conjunction with atomic energy.

Heat-Transfer Theory—Empiricism is giving way to better understanding of the fundamental mechanisms of heat transfer. Supersonic flight, nuclear energy and jet-engine developments here also are providing the chemical engineer with better tools for analysis and solution of his process heat-transfer problems.

Heat-Transfer Equipment—Greatest recent equipment development in the heat-transfer field has come about in gas-gas exchangers, notably for low temperatures. Standardization is an important aspect of the shell-and-tube exchanger line, with other developments in non-tubular types, easier cleanability, and improved construction materials. Reflecting the onset of water shortages in some areas, the air-cooled exchanger has made important inroads in recent years.

CECIL H. CHILTON
THEODORE R. OLIVE

JOSEPH C. McCABE, author of this article, has been associate editor of **Power** magazine, New York, for the past seven years. Born and raised in New Jersey, where he still is a resident, he is a licensed professional engineer in that state. After taking his B.S. in electrical engineering at Lehigh University, he directed his graduate interests toward mechanical engineering at Stevens. He still follows the latter persuasion, with specialties in fuels and combustion, air pollution control, and industrial power and water treatment. In the American Society of Mechanical Engineers he is program chairman for the Fuels Division. In the National Association of Power Engineers he is director of the Air Pollution Committee. Outside business hours, his interests run to local municipal affairs, particularly education, and to youth guidance activities such as the Little League.

Fuels—Choice and Handling

Price and availability are only two among several factors that are important in the choice of fuels.

In the United States today the fuels picture is one of wide open competition. At the moment there are relatively ample supplies of the three basic fuels—bituminous coal, oil and natural gas. Distribution and its costs prove the major factor in any regional predominance of one fuel over another. Natural gas and oil, of course, pretty well dominate the Texas and Gulf coast areas, as well as the far west. Coal, quite naturally, enjoys top preference in the north central states.[1] The eastern states, from the deep south to New England, though, are rapidly emerging as the major battlefield where comparative fuel advantages are fought out at almost every basic fuel price change. This is clear from Fig. 1.

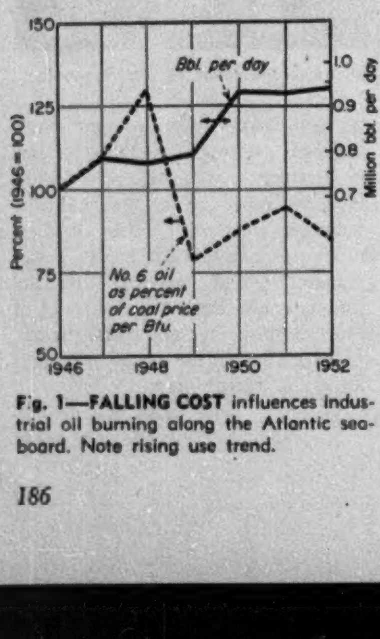


Fig. 1—FALLING COST influences industrial oil burning along the Atlantic seaboard. Note rising use trend.

Behind this battle is the long scramble of the major fuel producers for top position in the American market. Consider the case of the coal industry. For long years it has been going to more and more mechanization to offset rising labor and marketing costs. A ton of coal now wholesales in New York, for example, at close to $10, including freight and handling costs. Mine mechanization has equipped the industry to produce far greater tonnage today than ever before. Yet, as an industry, the coal producers have never succeeded permanently in affecting the 40-year average of 486 million tons output per year of bituminous coal—this despite the fact that overall fuel demand has just about doubled in these same 40 years. As an example, 1952 production was only 1.2 percent above that of 1951.

It has been the oil industry, with its direct service outlets to the transportation market, that has met most of this extra fuel demand. In fact, in servicing the transportation market and producing its needed gasoline, kerosene and light distillate oils, the refiners have found a waiting outlet for their residual oils among the traditional solid fuels markets—heat for steam and process. As Fig. 1 emphasizes, this has been true particularly when the price was right. In January 1953 heavy fuel oil sold in New York at 84 percent of the price of coal on a Btu. basis. Consequently, a large share of the growth in demand for the heavier fuels has been absorbed by residual oils in this area. Such oils increased 5 percent over 1951 along the Atlantic seaboard.

To keep ahead of their demands the oil refiners have gone abroad, developing middle eastern and South American fields, so that today approximately 1 million of the 7½ million bbl. per day of domestic demand for petroleum comes from foreign sources, mostly entering at east coast ports. Eastern states markets are likely to take still more foreign oil if the demand growth continues.

On top of this stiff competition between liquid and solid fuels is the bid the natural gas industry is making—a jump of about 19.5 percent in 1952 over 1951. The industry is continually pushing gas transmission lines farther and farther into the rich eastern market. Once this fuel is made available in any area, there is no question that gas will get a sizable share of the business, especially on a cancellable dump supply contract with its attractive rate structure.

FUEL TRENDS

So much for the present supply picture. What does the future look like? Coal, of course, enjoys a tremendous potential for the long haul. Last summer's report of the President's Material Policy Commission (Paley report) estimates that coal will go up sharply in its relative position in the fuel picture. For utilities alone it will supply something like 75 percent of the fuel needs by 1975, against today's 65 percent. And this at a much higher demand rate—so that it will amount to something like 320 million tons against today's 100 million. And coal may be expected to increase its uses as a chemical raw material even more than as a fuel.

Oil's future also is a highly interesting one. Whether you rank it as optimistic or not is pretty much a matter of where you get your information. The Secretary of the Interior among others sees a synthetic fuel industry drawing liquid fuels from coal and oil shale as a necessity in the not-too-distant future. The oil industry sees it differently,[2] as forecast in Figs. 2 and 3.

By the end of 1967 Fig. 3 estimates cumulative crude-oil discoveries at 120 billion barrels, with proved reserves

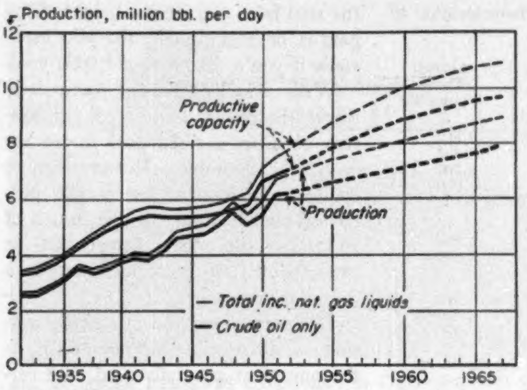


Fig. 2—CRUDE OIL productive capacity keys close to production in the U. S.

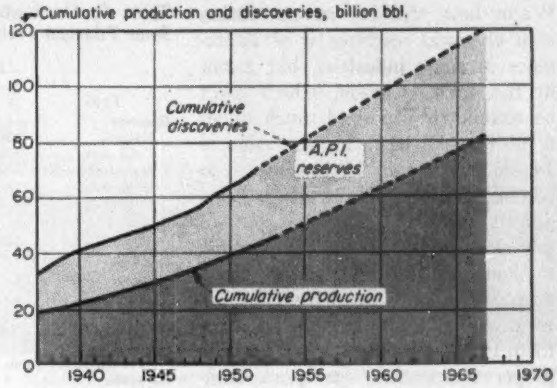


Fig. 3—CUMULATIVE U. S. oil production and discoveries suggests the future trend.

standing at 38 billion barrels. This is about 13 times the then current rate of production according to the refiners' best guesses. Barring a major war with complete cessation of imports, this should provide a comfortable margin for some time to come.

Where is it all coming from? The Williston Basin of the Dakotas and Montana, the offshore areas of Texas and Louisiana, and the deep pays of the Permian Basin in Texas offer the additional oil supplies for future needs. There is, however, no detailed forecast of the quality of crude oil that will be available 15 years from now. From the information sources just mentioned it looks as if there will be a higher proportion of low-sulfur crude than in the recent past.

Over and above these sources is the excellent record of the refineries in recovering liquids from natural gas. Repressuring has proved a valuable tool in pulling out oils from known reservoirs and producing large quantities of liquefied petroleum gas and natural gasoline. As time goes by indications point to still more natural-gas-liquids extraction plants installed along the large interstate gas pipelines to recover propane, butane and heavier materials suitable for industrial or residential consumption.

There are still other possibilities that appeal strongly to the imagination. Present oil production methods recover an average of only about 25 to 35 percent of the oil in place in the ground. Where natural water drive is present, as in East Texas, yields run as high as 80 percent. Where water injection can be used, recoveries climb to 40 to 60 percent. There are still other methods at the laboratory stage, as yet untried in the field, that may raise the yield everywhere. If so the day when this country will be short of oil may be put back more years than we can now guess.

Natural gas shapes up as having the shortest life expectancy of any of the major fuels. Its present reserves have been put at about 200 trillion cu. ft., with possibly 400 trillion as the maximum to be uncovered.

It looks very much as if this fuel will enjoy a strong rise in demand to about 1960 because of the now widespread gas transmission lines. Something like 40 percent of the total marketed production in 1950 went across state lines, against 17 percent in 1925. Since 1950 the lines have gone into the heavily industrial northeastern areas of Pennsylvania, New Jersey and New England. But it stands to reason that newer industries or plants arriving on the scene after say 1960 will consider the future possibilities of this fuel as a poor long-range risk and hence decide not to use it at all.

Why should oil and natural gas enjoy so ready an acceptance wherever they can be made available? Chief reason is their ease of firing, followed very closely by relatively simple storage and handling problems.

Table I—Comparative Properties of Major Fuels

Characteristic	Coal	No. 6 Oil	Gas
Impurities	Vary with quality; up to 20% or more, mostly pyrites, calcites, silicates. Ash may prevent coal use in some direct-fired processes.	Sulfur, asphalt, vanadium. Traces of others. Total may be 6–10%.	Relatively slight; sulfur in traces.
Corrosive action	Reducing atmosphere or SO_3 in combustion gases highly corrosive; scaling tendency in lower temperature zones.	Same as coal combustion gases, but vanadium scaling is more difficult to remove.	Usually very little if sulfur compounds are properly removed.
Flame length	Variable with firing method; pulverized firing gives longest flame, but controlled by burner design.	Fully controlled by burner design.	Fully controlled by burner design.
Explosibility	Explosions possible from faulty or interrupted ignition if incompletely burned gases are present. Flame-failure safeguards apply.	Flash point is critical but explosion is most likely from same causes as coal. Correction is the same.	Explosive mixture is needed for combustion. "Programming" controls are best safeguard.
Storability	Requires relatively large storage area and volume (50–60 cu. ft./ton) and careful compaction to avoid spontaneous heating.	Tankage easy to provide. However, industrial fuel oils require heating to reduce viscosity at burner.	Impractical for user to store in most cases, except surge volume.
Waste products	Mostly up stack as flue gases. Ash can be tapped as slag or dumped to cool. Fly ash may be a problem with pulverized fuel. High sulfur may cause complaints.	Usually no problem; all waste is flue gas which is generally inoffensive with proper combustion.	Same as oil.

COMBUSTION CHARACTERISTICS

The most fundamental principle of combustion is that no fuel truly burns unless or until it is a gas. The extra equipment such as coal crushers, pulverizers and stokers for solid fuels, and preheaters and atomizing burners for liquid fuels, are merely mechanical aids in breaking these fuels down to the point where their combustible elements can act as if they were gases in the furnace chamber.

Carbon and hydrogen, of course, are the principal combustible elements regardless of the type of fuel, with sulfur and other burnable elements negligible in overall effect.

Waste heat recovery in connection with chemical reactions is of importance in some industries, but minor in the total. Carbon, which can't be completely vaporized much under 6,300 deg. F., has a heating value of 14,500 Btu. per lb. Hydrogen runs to 62,000 Btu. per lb. Carbon and hydrogen combined in the forms of gaseous hydrocarbons, principally methane, make up the most important constituents of the major fuel gases, and all that is needed to burn them is the right blend of air and the proper temperature for quick combustion.

The exact value of the ignition temperature, the lowest temperature at which combustion will occur, depends to some extent on surrounding conditions and usually refers to combustion in ordinary air. Among other conditions, pressure affects ignition temperature, lowering it for high pressures. Table II gives an indication of the burning properties of the major fuels. More on the combining of air with fuels for combustion, the methods used and the steps that occur will be found in the combustion section of this report.

Table II—Combustion Characteristics of Some Principal Fuels

Type	Heating Value, Btu.[1]	Approx. Flame Temp., °F.[2]
Gaseous		
Natural	950–1,150	3,562
Coke oven	500–600	3,630
Manufactured	500–600	3,700
Producer	135–165	3,010
Butane	3,200–3,600	3,450
Liquid		
No. 5 oil	146,500	3,300
No. 6 oil	148,000	3,000–3,100
Solid		
Bituminous coal	12,000–14,000	3,000
Coke	13,000	2,800–3,000
Lignite	7,000	2,800–3,000

[1] Per cu. ft. for gases, per gal. for liquids, per lb. for solids.

[2] No excess air for gases, 10% excess for liquids, 20% excess for solids.

STORAGE AND HANDLING

In addition to ease of firing, storage and handling are important factors in the choice of fuel. Unless ample supplies of natural gas, for example, are readily available it is impractical for a plant to rely on this fuel. Storage for an individual plant would be out of the question. Large enough storage tanks or underground reservoirs would represent an investment far outweighing the advantage of ease of firing compared with other fuels.

Oil, though, is quite a different matter. It can be stored safely and conveniently. With proper foresight the handling elements can be made adequate for almost any liquid fuel so that oil system complaints of other years need not re-occur. For example, oil refineries regularly burn liquid pitch or asphalt which is solid below 200 deg. F. However, such wastes are never allowed to cool so that viscosity is always maintained at a pumpable level.

Here are a set of recommendations that will give trouble-free oil storage and handling. Provide ample-sized insulated storage tanks, two fuel-oil pumps with adequate drives, twin strainers for each pump, suction lines from each pump to each storage tank. Then make certain that fuel oil temperature—and hence viscosity—is adequately controlled; that circulation is good and positive to assure hot oil reaching each oil burner or set of burners; and that pressure on the fuel oil supply is at the proper level at the control valves. It is also smart to make provision to condition the fuel oil after delivery, that is, to introduce additives to control sludge or remove water, and to have enough instruments so oil supply and handling can be properly recorded and supervised.

There is plenty of know-how today to avoid the usual problems in storage and handling of solid fuels. Coal's biggest drawbacks in this regard lie in the space taken for storage, and the equipment and care needed for the proper movement of coal into and out of storage.

There are two basic storage methods, both intended to control air movement through the storage pile and prevent spontaneous combustion. In one the idea is to insure a heavy flow of air through the pile, so much so that any heat generated is carried away before it can build up appreciably. The second is the exact opposite. It is designed to shut out all possible outside air.

The free air-flow method depends on ample air space throughout the entire coal pile. The fewer fines present, the better are this method's chances for success. Because of this, sized coal—nut, stove, egg and lump—gives the best results. Take every precaution to see that the coal does not get broken up or compacted in the storage operation. Avoid dropping the coal from too great a height, dragging it, or tracking over the pile, especially if you're handling a friable coal.

With smaller plants, particularly where the coal is hand-fired, this system of using a sized coal in storage is highly desirable. However, most coal for steam-plant use is not purchased already sized. In fact, much of it reaches the plant storage yard as run-of-mine, and must be stored in a different way.

The second method of storage, cutting off all possible air movement, is the one most generally used, and certainly so on large storage piles. First step is to eliminate segregation. If you dump coal on a storage pile by bucket or belt, you'll find the coal always segregates. The fines stay in the center of the pile and the coarse lumps roll to the outside, an ideal set-up for spontaneous combustion.

To prevent segregation you have to rehandle the coal, spreading it evenly and uniformly over the storage area and then compacting it in layers. Compacting is most important. This method has several valuable features, chief among them being redistribution of the coal, and elimination of segregation. Also the packing action effectively changes the density. Loose coal has a density of roughly 50 lb. per cu. ft. Under ordinary storage piling this density builds up after a number of years to a maximum of 58 lb. in the bottom layer of a 20-ft.-high pile. However, coal compacted by bulldozers weighs between 65 and 70 lb. per cu. ft.

In general, there are definite recommendations on size that have been advanced for good compacting. Sized coal or coal from which fines have been removed does not lend itself to successful compacting. Run-of-mine coals should first be crushed or screened and the sized coal put in a separate pile very definitely isolated by a passageway from the compacted pile.

A properly compacted pile is spread out across the coal storage area by a drag or scraper and a bulldozer. The thickness of each layer is usually from 6 to 12 in. A second way of compacting is to use a heavy weight with a comparatively large surface area. When compacted and stored in this way the pile is hard and firm and will stand with vertical walls when excavated. Water runs off readily even on

Fig. 4—COAL RESERVES comparable to Commonwealth Edison's 350,000-ton pile at Ridgeway generating station are seldom needed at process plants, but do teach a lesson in handling and compaction methods.

a slight slope. By way of contrast, a segregated, uncompacted pile contains regular air flues between layers which inevitably invite fires.

The slopes are the weakest part of a compacted pile since segregation is there most pronounced. Wind can force air into the pile at this vulnerable spot. There are several ways to safeguard the slopes. If a bulldozer is used it can be run up and down the slopes frequently as the pile forms. However, this means a much less steep slope than the normal 45-deg. angle of repose, which is a disadvantage in limited storage areas. You can also use excavated basins with earth slopes or embankments having about a 2:1 slope. Both give fine protection but do offer some problems during coal removal. A recent improvement in coal storage is to seal the pile top and bottom to prevent air infiltration and reduce windage loss. Fines held in place by a thin cover of heavier coal, asphalt, oil or tar have all been tried successfully for this purpose.

NEW FUELS

There is a good possibility that nuclear energy eventually will compete with coal to a large extent if the breeder reactor processes now under observation pan out. Assuming continued use of the gaseous diffusion process it is estimated that coal consumption in connection with that process might eventually go to 22,500,000 tons a year. But with breeder reactors, the basic uranium will be converted to plutonium and energy, the latter already demonstrated as practical for power production. Four different industry groups, including 15 of the largest electric utility companies and several big chemical concerns, are studying commercial power production from atomic sources. The possibilities are tremendous despite high investment, since every pound of uranium which fissions can yield energy equivalent to 3 million lb. (1,500 tons) of coal.

Coal itself offers a number of new application ideas. Despite all the latest mechanization aids the unit output per miner has not improved appreciably. This is because the easy-to-get-at coal for both underground and strip mining is running out and it takes more equipment to hold the old rate of output. As a result the Bureau of Mines, along with the Alabama Power Co. at Gorgas, Ala., have been experimenting with underground gasification of coal with the idea of securing better than 80 percent of the available coal against the best underground mining records of 50 percent.

Their new approach—electrocarbonization—requires only drilling holes from the surface and inserting steel casings that carry an electrical conductor to an electrode at the bottom. When the current flows between pairs of electrodes a "burn path" develops. Then air, steam or oxygen are forced down the borehole to gasify the underground coke so that you get producer, manufactured or synthesis gas depending upon what medium you force down the borehole. The Btu. content runs from 80 to 300, and with a catalyst it has been suggested that it can be boosted to 1,000.

Low temperature carbonization is still another development on the coal front. Alcoa and the Texas Power & Light Co. are using the process at Sandow on lignite. Pittsburgh Consolidation Coal Co. is successfully operating the Disco process. In both cases the readily volatile portions of the fuel are driven off for chemical recovery or to make a rich fuel gas, leaving a char of 10,000-12,000 Btu. per lb. heat content. The char is then fired under boilers. In the latter case it is also used as domestic fuel.

PROCESS WASTES

Much of the present activity in the burning of process wastes stems from attempts to avoid stream or air pollution. For example, the pulp industry is now seriously attempting to control the sulfite waste problem by burning the concentrated waste liquor in a way similar to the smelting of sulfate process black liquor. The steel industry has long burned its blast furnace gas (100 Btu. per cu. ft.), as well as coke oven gas (500-600 Btu. per cu. ft.). These fuels were readily available, of course, but their use has had the added advantage of reducing atmospheric pollution and improving community relations. Similarly many other industries have burned their refuse, such as wood waste, coffee beans, furfural extraction wastes, bagasse, and so on down the line. However, such fuels are of value only where they are easily available. Furthermore, combustion offers the most convenient disposal. Although use of such waste fuels will probably increase in the future, like waste heat recovery operations they will continue to account for a relatively minor part of the nation's fuel energy needs.

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His present assignment is the design of a new combustion research installation which will extend the laboratory's activities to study of supersonic ramjets. He spent a year in research on stabilization of flames in homogeneous, high-velocity air-fuel streams. His post at the FRL is administrative assistant to Profs. H. C. Hottel and G. C. Williams.

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Hobbies are skiing and choral singing.

Combustion Theory and Practice

An appreciation of the fundamentals of combustion provides a better understanding of commercial burners.

The eminent historian, Carleton J. Hayes, once observed that the birth of chemistry as a science was delayed a century beyond the birth of physics because of entrenched misconceptions about the nature of combustion. Routing of the phlogiston theory, however, cleared the way for progress in the science of chemistry and in the art of making effective combustion equipment. Modern research has shed much light on the nature of combustion, but modern technology has in turn multiplied the number of combustion problems to be solved.

Briefly here we shall consider principles of combustion and operating features of combustion equipment.

REACTION MECHANISMS

Combustion, the exothermic reaction of fuel with oxygen from the air or some other source, does not occur unless the fuel is first in the gaseous state; mechanisms for the oxidation of gases therefore apply to all types of combustion. Investigations of the past 30 years show that the equation for the over-all chemical reaction does not describe the mechanism of any combustion process.

The simplest illustrative case, combination of hydrogen and chlorine, though it does not involve oxygen, is analogous to other oxidation reactions. Hydrogen and chlorine in stoichiometric proportions will not combine unless something is done to dissociate some of the chlorine molecules. When the chlorine is dissociated by light, hydrogen chloride is produced at explosive rates by the following reactions:

$$H_2 + Cl \rightarrow HCl + H$$
$$H + Cl_2 \rightarrow HCl + Cl$$

and so on, in which hydrogen and chlorine atoms are the carriers in a chain reaction.

The hydrogen-oxygen reaction is far more complex, but it, too, has been explained satisfactorily by a chain-reaction mechanism of many steps, in which hydrogen peroxide plays a key role as a trigger which dissociates thermally to provide chain-carrying species, OH, HO_2 and H. There is also fairly good agreement among investigators as to a chain-reaction mechanism for the oxidation of carbon monoxide.

In the case of hydrocarbon oxidation, chain mechanisms involving the formation of aldehydes and peroxides as intermediates are indicated, but the complex details are far from fully formulated.

The combustion of solid carbon is a physico-chemical process in which the physical and chemical histories of the material are important factors in determining the reaction rate. Extensive studies have led to the conclusion that oxygen atoms which reach the carbon surface by diffusion are adsorbed and form a complex with the carbon atoms. Decomposition of this complex and chemical reaction follow. At temperatures below 1,650 deg. F., a mixture of oxides is produced; above that temperature, carbon monoxide predominates. Carbon dioxide is then formed by the fast chain reaction in the gas phase.

Carbon combustion is of interest not only in the burning of coal, our most important fuel, but also because carbon is often an intermediate in the combustion of gaseous and liquid fuels. When these latter are heated sufficiently in an oxygen-deficient atmosphere, thermal cracking occurs, in stead of combustion by the hydroxylation route. Cracking yields fine carbon particles, which subsequently burn with a yellow, luminous flame of high radiant emissivity. This is desirable for some types of heating processes, notably the metallurgical. In other cases carbon formation is undesired, especially where too quick cooling causes combustion to cease and the carbon remains as soot or smoke.

In contrast to the chain-branching reactions by which combustion proceeds, there are chain-breaking reactions which, if predominant, can cause combustion to cease. One of the most important of these is the adsorption of active radicals by a cold surface, such as a metal burner wall or a screen. Since the maintenance of combustion can be explained by thermal as well as diffusion mechanisms, which are characterized by similar mathematical expressions, it is sometimes difficult to tell whether the quenching action of a cold surface is a chain-breaking effect or a thermal effect.

IGNITION AND FLAME PROPAGATION

Ignition of a combustible mixture occurs when the temperature and concentration of active species are high enough to cause oxidation at such a rate that energy released exceeds energy lost to the surroundings. Ignition can occur in mixtures having different fuel-air ratios; those which are just capable of sustained combustion represent the rich and lean limits of flammability.

Combustion, once initiated, propagates as a thin wave or flame front, which can be studied either as the moving surface of a sphere or as a layer fixed in space—the case of the conical flame surface above a bunsen

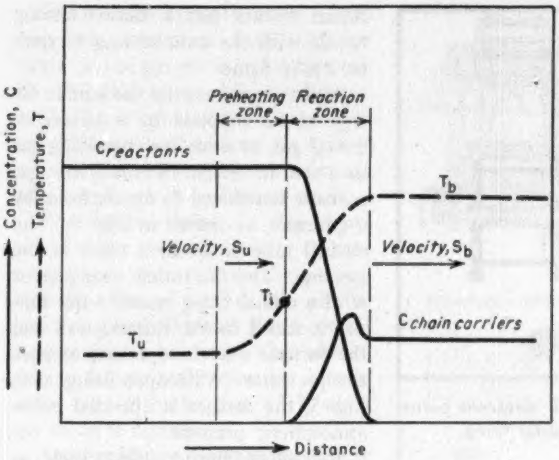


Fig. 1—SCHEME of flame propagation.

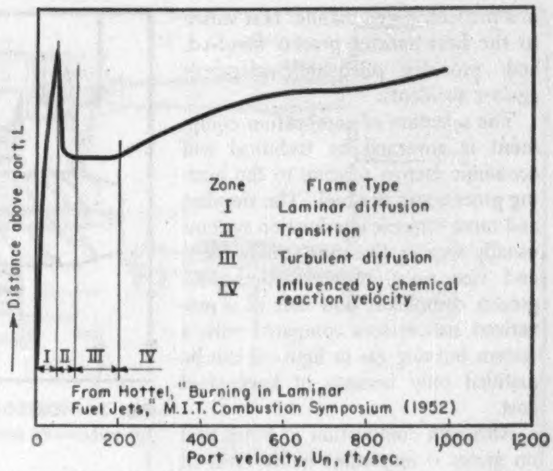


Fig. 2—LENGTH of flame vs. port velocity.

burner. The wave propagates in a direction normal to itself into the unburned mixture at a rate known as the burning velocity or flame speed.

Referring to Fig. 1, the unburned mixture with velocity S_u and temperature T_u approaches the flame front, which may be subdivided into a preheat zone and a reaction zone. In the first zone the unburned gas receives heat by conduction and active radicals by diffusion from the burning gas downstream. Reaction begins at the ignition temperature T_i and continues until the reactants are consumed; the temperature, velocity and concentration of chain-carriers at this point are those of hot, burned gas.

If the flame front just described is stabilized—held fixed in space—above the rim of a burner tube through which the gas flow is laminar, the flame front can be almost a straight cone. It is distorted somewhat at the base by thermal expansion and the quenching action of the rim. If the flow rate is increased and the flow becomes turbulent, the flame front becomes wrinkled and greatly extended in area. Here, the propagation normal to the flame front will be the same as before, and the laminar flame speed will still hold for all small elements of flame-front area, but the net effect is that burner throughput can be greatly increased and the so-called turbulent flame speed may be several times the laminar.

When the flow rate is further increased the flame will blow off the burner port, sometimes, under controlled conditions, continuing to burn as a lifted flame above the port.

If the flow rate is reduced the flame will reach upstream to get more fresh mixture, sometimes going all the way to the burner tube; this is flashback. If the tube is large enough the flame will propagate through it; otherwise it will be quenched by the cold tube walls.

By the use of special devices flame can be stabilized in an air-fuel stream at velocities much higher than blowoff velocity for a normal burner. One such device is the flame-retention burner, which has a pilot flame held in an annular ring around the main stream of gas.

Still more effective is a bluff object, such as a cone, rod, or V-gutter set normal to the flow. The gas streamline which hits a rod, for example, is diverted around it and, in consequence of an adverse pressure gradient, is bent into eddies on the downstream side, recirculating toward the low-pressure region there. The eddy gases move slowly enough so that a spark applied will cause combustion to start. Flame in the wake region then serves as a pilot source of heat and active species to promote propagation through the main stream of gas. Variants of this type of flame stabilization are used in high-output combustion systems such as those in turbojets and ram-jets.

COMBUSTION OF UNMIXED FUEL JETS

It is sometimes desirable to burn an unmixed fuel jet, allowing mixing and combustion to proceed simultaneously. This is the cheapest heating process in some furnaces, or it may be desirable to get the high emissivity of radiant heat obtained from combustion of the carbon formed in the flame.

The flame of a pure fuel jet burning in quiet air is characterized by its length and appearance, which are strongly dependent on the jet velocity. The variation of flame length with port velocity is shown schematically in Fig. 2. At low velocities the mixing which must precede combustion is accomplished by the slow process of molecular diffusion. In this laminar flame region, Zone I, flame length increases rapidly with increasing jet velocity. Zone II is a transition region where turbulence so speeds the mixing process that the flame actually becomes shorter while fuel is supplied faster. In Zone III, turbulence is fully developed, and mixing keeps pace with increased fuel flow.

In all the first three zones the chemical reaction is relatively so fast that mixing time controls the over-all process and thus the flame length. With jet velocities higher than about 200 or 250 ft. per sec., however, the time required for reaction becomes the controlling factor. Thus, in Zone IV flame length increases slowly with increased jet velocity. A pilot ring near the gas port is necessary for stabilization of such a flame at velocities higher than 300 ft. per sec.

FUNCTIONS OF COMBUSTION EQUIPMENT

A complete combustion system prepares the fuel, delivers it at the desired rate to a burner or grate, provides a supply of air in the right amount and at the right place, controls combustion

in a predetermined manner best suited to the heat-transfer process involved, and provides adequate safeguards against accidents.

The selection of combustion equipment is governed by technical and economic factors relating to the heating process and the fuel. The simplest and most versatile combustion systems usually require the most costly fuels, and vice versa. Obviously, the far greater complexity and cost of a pulverized coal system compared with a system burning gas or light oil can be justified only because of lower fuel cost.

Although combustion of lump coal on grates is important in the over-all economy, this article neglects grates and stokers for three reasons: (1) Even in large central stations and industrial generating plants the trend is towards oil or pulverized coal; (2) lump coal is rarely suitable for modern process heating jobs requiring flexibility and accurate control; and (3) design of grates and stokers is chiefly a mechanical problem—one of materials handling—and is usually considered part of the furnace design.

PULVERIZED-COAL BURNERS

Coal can be burned most rapidly and efficiently if pulverized to particles of 20- to 100-micron size for suspension firing. Mechanical pulverizers use ball mills, hammers or balls in races for pulverizing coal by crushing, impact and attrition; a stream of preheated air serves to dry, transport and classify the coal. In some newer pulverizers size reduction is accomplished by attrition between coal particles propelled by high velocity steam jets.

Pulverized-coal burners blast the suspension into a furnace in a cyclonic motion. Primary air burns the volatile matter which is distilled from each coal particle within a fraction of a second after it enters the furnace. The particle is heated to incandescence by this combustion of volatile matter and is ready for the scouring action of secondary air to effect complete combustion. A typical pulverized coal burner is shown in Fig. 3.

GAS BURNERS

Depending on the nature of their provision for mixing gas and air, burners can be classified as premixing, nozzle-mixing, or luminous-flame (furnace-mixing) burners. The concen-

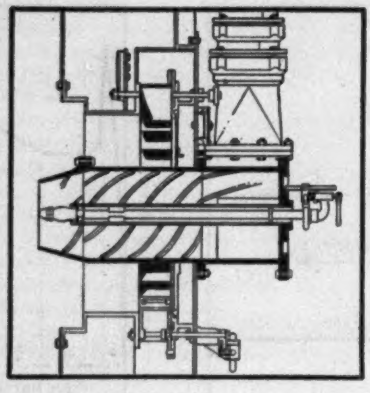


Fig. 3—HORIZONTAL turbulent burner for pulverized coal and oil firing.

trated blue flames of the first two types allow high volumetric heat release rates—from about 100,000 Btu. per (hr.) (cu. ft) in low-velocity systems up to 40 million Btu. per (hr.) (cu. ft.) in pressurized high-velocity systems. The long, luminous flame, on the other hand, may have several times more radiating power at a given temperature and can provide more uniform temperature in a furnace, although its output is limited to about 40,000 Btu. per (hr.) (cu. ft.).

In most premixing devices kinetic energy of the gas or the air is used to inspirate the other fluid and do the work of mixing. In the atmospheric burner common to household gas ranges and small industrial furnaces, gas at 2 to 10 in. w.c. is fed through a spud (orifice) to a venturi mixer. Because of the resulting low pressure at the venturi throat, air is inspirated. As the two streams approach the throat and merge, the difference in their velocities sets up shear forces which promote turbulent jet mixing. From 40 to 60 percent of the total air required can thus be mixed with the gas; provision must be made for uniform distribution of secondary air around the burner ports. Fig. 4 shows an atmospheric burner for a heating boiler, designed for using gas at 4 in. w.c. and essentially constant capacity.

The high-pressure inspirating burner is like the atmospheric except that it uses gas at pressures of 1 to 30 psi., preferably not less than 5 psi. All the air required for combustion can be inspirated or, if control of flame length is desired, designs are available which permit turning down the primary and introducing secondary air. Fig. 5 shows such an arrangement; this particular burner has a flame-retaining nozzle with the annular ring to shelter a pilot flame.

Aspirating mixers use the kinetic energy of air supplied by a blower at ½ to 2 psi. or more for entraining gas in a venturi mixer. Normally the gas pressure is reduced to atmospheric by a governor, as shown in Fig. 6. The air-fuel ratio is set by a valve in the gas line. The illustrated arrangement is of a closed firing system—the burner is sealed to the furnace wall and the furnace may be operated at positive pressures. With open firing, as in Fig. 5, the furnace is operated below atmospheric pressure.

Refractory burner tiles, such as shown in both Figs. 5 and 6, may be conical, cylindrical or venturi-shaped for various types of burners. The hot tile radiates to the incoming unburned mixture, thus assuring ignition and reducing the possibility of blow-off or flash-back in the event of sudden pressure changes.

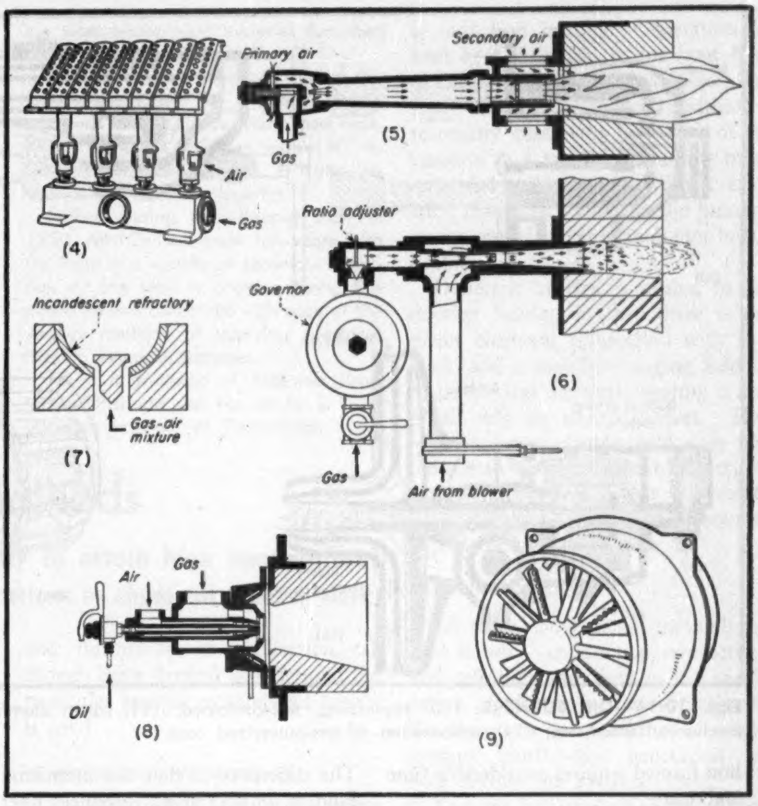
With either the inspirator or the aspirator mixer a single valve controls the flow of air-fuel mixture to the burner, because with fixed orifices the flow rate of the entrained fluid is always proportional to that of the entraining. The upper limit of capacity depends on either the pressure of the fluid that supplies mixing energy or the approach to blow-off velocity; the lower limit is set by approach to flash-back velocity. Safe minimum mixture pressures for atmospheric firing are 0.25 in. for natural gas, 0.50 in. for faster-burning manufactured gas. The turndown ratio is equal to the square root of the ratio of maximum to minimum pressure-drops.

In another type of premixer the air and gas are drawn together through a gastight blower and the mixture is delivered to one or more burners. Valves which are a part of the assembly permit accurate setting of the air-fuel ratio to maintain oxidizing, neutral or reducing atmospheres over a wide capacity range. A flame-check between the burner and the blower is obviously required. A popular type of burner for use with premix machines is the refractory-cup burner shown in Fig. 7. The air-fuel mixture impinges on the surface of a combination burner tip and burner block. The refractory surface is at close to white heat and acts as a high-temperature, high-emissivity source of radiant heat.

The nozzle-mixing burner is a type singularly safe from flash-back, because air and gas are kept separate until within the burner tile in a furnace wall. The simplest of these has a multiport burner head to eject gas against the tile and vanes to swirl the air which is drawn in by furnace draft.

The burner shown in Fig. 8 receives under pressure separate streams of gas and air, automatically proportioned. (Use of part of the air for atomizing fuel oil makes this a combination gas-oil burner.) The nozzle-mixing feature makes possible a turndown ratio of better than 15:1, when gas alone is burned.

Another burner designed for mixing air and gas immediately before combustion is the Fanmix burner. Gas at 1 to 30 psi. issuing from jets in spider arms rotates the spider and its hub as a reaction motor. Fan blades mounted on the hub draw air through the back of the burner and blow it into the furnace nearly normal to the direction of initial gas flow, promoting good mixing and short-flame, high-capacity combustion. The model shown in Fig. 9 has alternate spider arms designed for ejecting steam-atomized oil, making this also a gas-oil combination burner.



Figs. 4-9—GAS BURNERS: (4) Atmospheric; (5) inspirator, with flame-retaining nozzle; (6) aspirator; (7) refractory cup; (8) nozzle-mix combination; (9) Fanmix.

Luminous flame burners are designed for low-velocity admission of air and gas, free of turbulence, to the furnace. The air surrounds the gas, combustion occurs at the interface, and, by heating the core of gas, promotes thermal cracking and the carbon formation prerequisite to a long luminous flame.

A combustion application of particular interest to chemical engineers is the submerged combustion process. Developed originally for concentrating sodium sulphate solution without the severe scaling problem that attended use of tubular evaporators, the process consists of burning gas and air, either premixed or nozzle-mixed, in a burner submerged below the surface of a liquid in almost any type of tank. Hot combustion products issue directly into the liquid from a conical burner or from a perforated pipe which extends below the burner nozzle and along the bottom of the tank. Burner submergence is normally about 4 ft. below the surface, requiring relatively high-pressure gas-air mixtures to overcome the liquid head.

Heat transfer from combustion product bubbles is rapid and uniform. Heat-release rates are as high as 4 to 5 million Btu. per hr. per cu. ft. of combustion space. The turndown ratio is limited to about 2:1. While originally used to solve a scaling problem, submerged combustion is efficient in other processes of liquid heating or evaporation and in recarbonation of water. Fuels used normally are natural or liquefied petroleum gas, or in some cases No. 1 or No. 2 fuel oil.

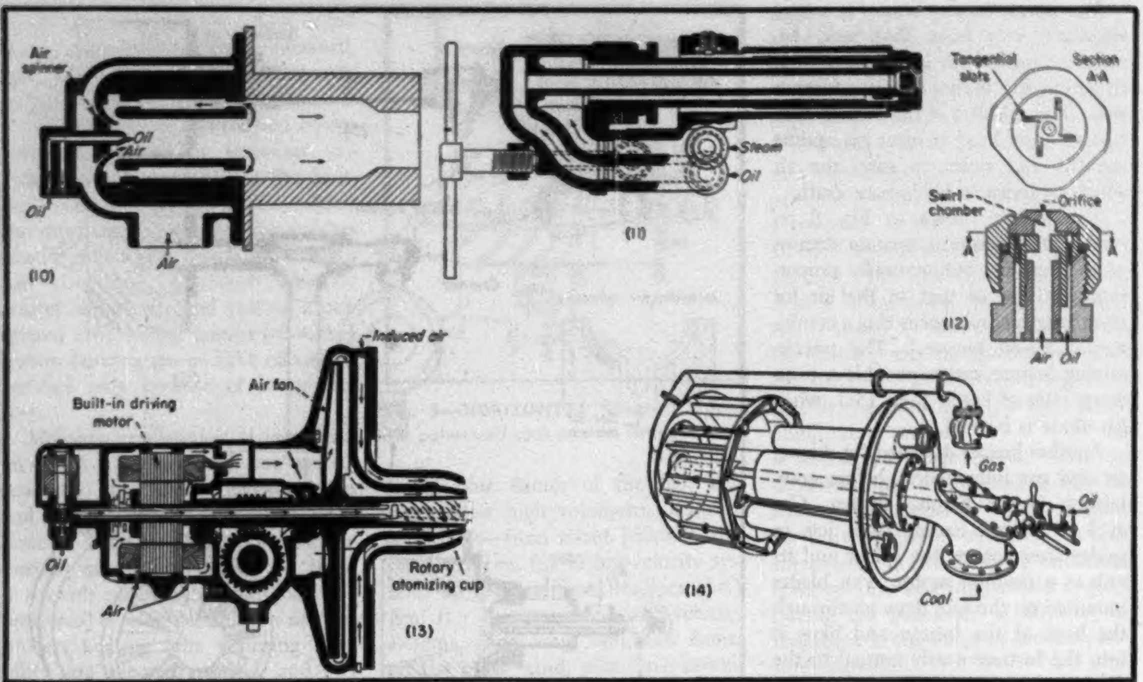
OIL BURNERS

Vaporization is prerequisite to combustion of fuel oil. This can be performed as a separate first step, with vaporized oil and air fed to the burner. In one such unit, products of combustion from a pilot flame heat and vaporize the oil by direct contact in a chamber. This separate vaporizing system is used with some domestic and small-scale industrial burners, or as a standby source of gas.

An oil burner recently introduced (see *Chem. Eng.*, Feb. 1953, p. 208) vaporizes the oil in a chamber which is part of the burner assembly. As shown in Fig. 10, a portion of the hot combustion gases are recirculated by air inspiration to provide the heat for vaporization. No burning takes place in the vaporization zone, since the mixture velocity is higher than the velocity of flame propagation. Any of the common distillate oils can be used, with work under way to develop a suitable design for burning residuals.

In all large industrial systems, vaporization occurs in the furnace, preceded by atomization of the oil to particle sizes mainly in the 10 to 50-micron range. Most atomizers can handle light and medium fuel oils at ambient temperatures; the cheaper residuals, Nos. 5 and 6, must be preheated to about 200 deg. F. for viscosity reduction.

Oil droplets entering the furnace at high velocity are simultaneously exposed to radiant heat from the burner tile and the scouring action of an air blast. A race between vaporization and thermal cracking occurs. The larger drops, especially those of low-volatile residual fuels, are likely to be cracked, and combustion of the car-



Figs. 10-14—OIL BURNERS: (10) vaporizing, self-contained; (11) steam atomizing; (12) pressure atomizing; (13) rotary mechanical atomizing; (14) combination oil-gas-pulverized coal.

bon formed requires considerable time and space.

Oil burners are classified according to the means used for atomization. Low-pressure air-atomizing burners, such as the oil-burning part of the dual-fuel burner in Fig. 8, use air at 1 to 3 psi. for atomizing oil supplied at 5 to 10 psi. Swirl vanes in their respective delivery tubes cause counter-rotation of the main and atomizing air streams as they leave the burner nozzle; this promotes turbulent mixing with the oil. Turndown ratio is governed by atomizing air required, which may be 10 to 20 percent of the total air. These burners have low first cost and operating cost. They are widely used in the numerous industrial applications which do not require the high output and efficiency possible with some other types of burners.

High-pressure air or steam-atomizing burners atomize the oil within the burner in some models and at the nozzle exit in others. Internal mixing followed by travel down a long tube is likely to give the oil droplets a chance for reaggregation. External mixing works on the same principle as does the low pressure system, that is, a cyclone of steam or air tears the oil into droplets as it leaves the nozzle. The difference is that the atomizing fluid at 75 to 150 psi. produces finer atomization, faster evaporation and mixing.

Steam is frequently used because its general availability makes for low first cost. But steam atomization increases the combustion space required and reduces thermal efficiency, as compared with air atomization. Use of air also provides wider capacity range (better than 20:1) since the atomization air is only about 3 percent of that required for firing at full load. A burner of this type is shown in Fig. 11.

Pressure-atomizing burners use energy of the oil itself for atomization. At pressures up to 300 psi. the oil is discharged into a small swirl chamber (see Fig. 12) through tangential slots and from the swirl chamber out through an orifice to the combustion space, in the form of a 60 to 80-deg. spray cone. Some nozzles have many oil jets, spaced around a nozzle head and set to discharge toward a tunnel wall. Combustion air (primary) is mixed with the oil either inside or immediately outside the swirl chamber.

For good atomization the pressure drop across the nozzle should not be varied more than about 2:1. Since pressure drop varies with the square of throughput, turndown is thereby limited to 1.4:1. In some burners the turndown is increased to 4:1 by use of a plunger to shut or open some of many openings from the oil tube to the swirl chamber. In another burner the full-load oil flow is continuously delivered to the swirl chamber, but for lower firing rates a controlled fraction is recycled to the pump inlet. Maintenance of a constant differential between supply and return pressure insures uniform atomization over a turndown range of 15:1.

The rotary mechanical atomizer (Fig. 13) feeds oil to a conical cup which spins at 3,500 to 10,000 rpm. As it leaves the cup the oil tends to fly out as a thin sheet normal to the cup axis, owing to centrifugal force. At this point a cyclonic blast of air parallel to the cup axis hits the oil, atomizes it, and promotes rapid evaporation and mixing. The turndown ratio of this type of burner is about 16:1.

Burners which use pressure or rotary mechanical atomization are generally used for space heating and steam generation where their short flames, high output, high combustion efficiency, and low power consumption for atomization offset high installation costs.

(Continued on page 221)

CECIL H. CHILTON, associate editor of Chemical Engineering, prepared this article from background material furnished by Westinghouse Electric Corp.

Thanks are due especially to the following individuals for checking certain sections: L. H. Gillette, resistance heating; J. D. Hall, infrared lamps; C. R. Olson, arc furnaces; and R. E. Kirby, induction and dielectric heating.

Before joining the editorial staff in 1950, Mr. Chilton spent ten years with Du Pont in a variety of technical activities. At one time or another during this period he was concerned with each of the various methods of applying electrical heat to chemical processes.

He is a graduate of Alabama Polytechnic Institute and has an M. S. from Carnegie Institute of Technology.

Electric Heating Methods

Ease of control or ability to attain high temperatures account for many applications in chemical process work.

Growing use of electrical heating methods by industry is a reflection of two trends–the relative cost of electric energy vs. fuel energy is becoming more favorable, and more and more industrial processes require the application of heat under conditions which inherently favor the use of electrical methods.

As any householder knows, electricity has to be dirt cheap and fuel sky-high to make space heating with electricity economical. Such conditions might obtain only in very limited parts of the world, notably in Norway. Electric heating is used, therefore, only when it can compete with combustion of fuels on other counts than the direct cost of therms of energy.

One of the most important and useful attributes of electric heating is the ease with which high temperatures can be attained. There is no problem with maximum flame temperature or reversible reactions; the only real technical problem is with materials of construction. And even this difficulty is lessened by the fact that many electrical heating applications avoid oxidizing conditions.

The absence of products of combustion eliminates the need for stacks or flues. There is no soot or ash, hence no disposal or pollution problems. Heat can be applied directly in an evacuated space.

Finally, electrical heating offers certain advantages as to ease of control and uniformity of application, although these depend largely upon the particular heating method and how it is used.

CLASSIFICATION OF METHODS

For commercial applications there are only two basic methods by which electrical energy is converted into heat —resistance to flow of current through a conductor and excitation of molecules in a nonconductor.

For practical purposes, however, the term resistance heating ordinarily applies only where a voltage is directly impressed across a solid conductor, such as a Nichrome wire, which can either be exposed to the surroundings or protected with a sheath of a suitable material.

Although purposely excluded by this definition, infrared heat lamps are basically another embodiment of resistance heating. Because use of lamps involves a different approach. however, than resistance heaters in general, this rather artificial separation of the two is generally recognized.

The third form of electrical heating depending on resistance to flow of current is the electric arc. Here the resistor is a gas or vapor, whose source is usually one of the electrodes. For example, the industrially important carbon arc is essentially the flow of electricity through an atmosphere of carbon vapor.

A more distant relative, but still part of the resistance heating family, is induction heating. Generation of heat here, however, is not from flow of current in a primary conductor, but from a current induced within a secondary conductor by virtue of its position in a rapidly fluctuating magnetic field. There is no direct electrical connection between the primary power supply and the conductor being heated.

Dielectric heating is related to induction heating in that there is no direct electrical connection with the work, and a rapidly changing field is required. But dielectric heating is applied only to nonconductors. The high-frequency electric field does not induce an electric current; rather, it is a voltage effect. Heat is created by stressing the molecular structures within the nonconductor.

TRANSFER OF HEAT

All three conventional methods of heat transfer—conduction, convection and radiation—are used in the application of electrical heating methods. To these we must add a very important fourth—the generation of heat within the material itself.

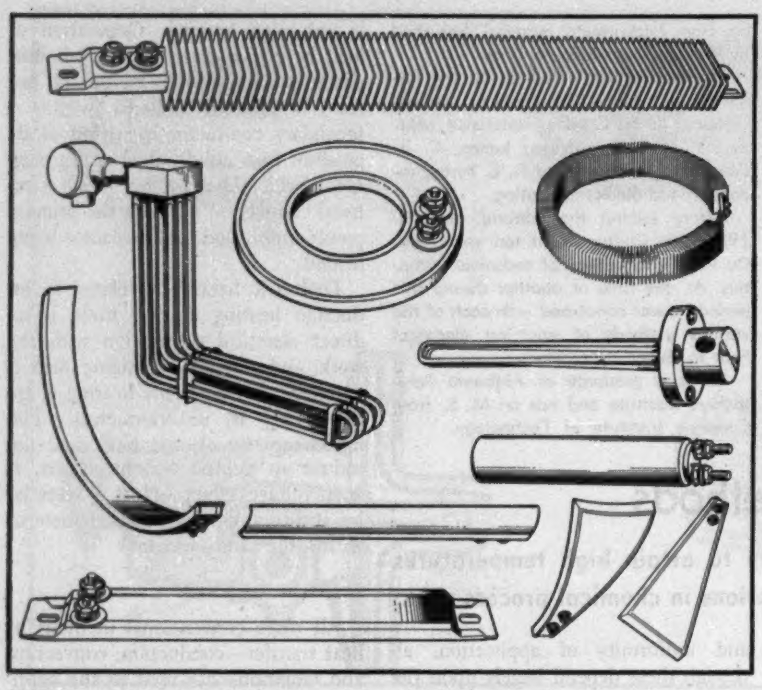
Transfer by conduction often occurs with straight resistance heating. The resistance elements can be attached directly to and in contact with the material or vessel to be heated.

Convection also occurs frequently in the application of resistance heaters. Heat is transferred from a resistance element immersed in a fluid through a fluid film to the surrounding fluid by the mechanism of convection.

Radiant heat transfer is the predominant mechanism in the use of infrared heat lamps. Since the filament is at practically white heat, rapid transfer can be obtained. The same is true also for arc heating, with the arc itself as an extremely hot source of radiation.

Although straight resistance heating elements don't operate at such high temperatures, often transfer of heat by radiation is quite practical. The surface area of the elements is made large enough to permit dissipation of radiant energy at the required rate.

Generation of heat within the material itself gives electrical heating methods a unique advantage in process work. This is especially true with dielectric heating, where the interior portions of materials of poor thermal



TYPICAL multi-purpose metal-sheathed resistance-heating elements.

conductivity can be quickly heated without having to transfer heat inwards from the surface. Again, in many applications of arc furnaces the electrodes are actually submerged in the charge and much of the heat is developed by the flow of electric current through the charge itself.

ENERGY RELATIONSHIPS

The rate at which electrical energy can be transformed into heat is expressed by the equation

$$P = I^2R$$

for direct current, or

$$P = 1.732\ I^2R \cos\theta$$

for three-phase alternating current, where P is the power in watts, I the current in amperes, R the resistance in ohms and θ the power factor. Good design, when using a.c., avoids inductance and unbalanced phases so that power factor is kept as high as possible.

Since there are no products of combustion to carry away part of the energy, all of the energy input is potentially available for use in the process. Where the process permits complete enclosure and good insulation the efficiency (ratio of useful energy to input energy) can approach 100 percent. With some types of electric heating, however, there are unavoidable losses in the frequency conversion or current rectification.

Although outside the scope of industrial electric heating, there is much current interest in the heat pump as a domestic space-heating device. The heat pump, in essence, uses electricity as a means of elevating the temperature level or availability of thermal energy stored in the earth. In a sense it provides useful heat to the extent of three or four times the amount of electrical energy consumed.

RESISTANCE HEATING

Although all but one of the commonly used methods of electric heating depend on resistance to flow of current, the most common usage of the term resistance heating applies to passage of a primary electric current through a metallic or nonmetallic conductor.

Resistance heating is an extremely versatile tool; it can be used for extremely light duties, such as household appliances, or for large industrial jobs. It can transfer its heat to the work by any or all of the mechanisms of heat transfer, including, in some cases, the use of the work itself as the resistor. Resistance heaters can operate in high-pressure atmospheres or in high vacuums. Their only limitations are the temperature at which the elements melt or the combination of temperature and atmosphere at which the elements oxidize or otherwise deteriorate.

These limitations are avoided insofar as possible by using materials of high melting point and resistance to oxidation. The most common metallic resistance elements are made of alloys consisting chiefly of nickel and chromium. A good nonmetal for resistance heating is silicon carbide. Carbon and graphite are suitable where they can be protected from oxidation.

The application of resistance heating in process work has been facilitated in recent years by the development of multi-purpose metal-sheathed resistance elements. These are available in a number of standard forms and ratings for light and medium-duty applications. They usually consist of a suitable resistor of Nichrome wire or ribbon embedded in a refractory, with the assembly surrounded by a protective metal sheath. The material of which the sheath is made can be steel, stainless steel, brass, lead, etc., depending on the proposed service conditions.

Strip heaters may be flat or curved, for attaching externally to tanks, reactors or pipes. Although individual elements are limited in rating, the usual installation employs a sufficient number of elements connected in circuits of suitable voltages and phases.

Immersion elements are used for heating liquids (or melting solids) in tanks, drums, tank cars or reactor jackets. They may have threaded or flanged connections to permit sealing into completely enclosed systems. Some are rated as high as 50 kw. and are available with three-phase wiring.

Complete prefabricated electric heaters can be bought in ratings up to 100 kw. for heating water, oil, Dowtherm, steam and air.

A recent development is a radiant resistance heater designed to compete with infrared lamps. A single element of suitable length is backed by a parabolic highly polished aluminum reflector. Certain advantages over lamps are obvious, such as less glare and more rugged construction.

The older devices for applying resistance heating are the conventional electric resistance furnaces and ovens. These may be classified as direct or indirect, depending on whether the work is exposed to the hot elements

or whether a muffle or some other surface is interposed between.

In its basic form a resistance furnace consists of a series of bare resistance elements arranged in a suitable electric circuit, suspended from or backed by refractory and insulating materials and radiating their energy to the work being heated. The latter may be the material being processed or it may be a container holding the material. Use of a container or muffle surface isolates the heating elements and protects them from damage or deterioration.

By conventional definition the electric oven differs from the furnace in that it usually operates at low to moderate temperatures (below 800 or 900 deg. F.) and the heat is transferred from the elements to the work principally by circulating hot air. This distinction is purely arbitrary.

Resistance furnaces can be designed for continuous process work. The material being heated can be propelled through the furnace mechanically or, where the material is a granular solid, the container or muffle can be slightly inclined and rotated in the manner of a rotary kiln.

A variation of conventional resistance heating utilizes the material to be heated as the resistor. Graphitizing furnaces, heating of aluminum and magnesium potlines, and electric glass and frit melting are typical examples. Where it is applicable this method has several advantages. It is efficient because the heat is generated where it is most desired. The enclosing structure or material, including the refractories, operates at a lower temperature than the heated material. With more conventional methods, the heating elements and furnace walls must operate at a higher temperature to provide heat flow into the material being heated.

Although no heating elements are required, electrodes are required to bring the electric energy to the material; these electrodes must operate at elevated temperatures.

The resistance of the usual materials heated by this method may vary radically with temperature. This usually necessitates a variable-voltage power source. The control equipment then is more complicated than with conventional resistance heating, where simple on-off control is frequently used. The most common types of equipment used to provide the variable voltage are tapped transformers, saturable reactors and induction regulators.

An interesting technique gaining increased attention for process applications is the heating of pipes by the resistance of the pipe itself. This system is useful where long lines would otherwise have to be jacketed or traced. For safety reasons such applications use fairly low voltages.

Design of a resistance-heating installation is rather complex. It is not sufficient merely to provide heating elements whose ratings total up to the required kw. output. One of the most important considerations often overlooked is the design of the heat-receiving part of the system. If heat cannot be absorbed from the elements at the required rate, the elements will overheat and may burn out. Even on simple strip-heater applications, the nominal rating of the heating element is based on good contact with the accepting surface. If this contact is impaired by corrosion, loosening, etc., troubles will occur.

With proper experience the process engineer can design and build his own resistance heating system. Although this may work out well on small jobs, the specialists in various manufacturers' organizations should handle the design of large commercial systems.

INFRARED LAMP HEATING

Incandescent lamps used for illumination purposes are designed to emit as much as possible of their radiant energy in the visible spectrum range consistent with satisfactory life. Infrared lamps, although they produce considerable visible light, emit most of their radiant energy in the longer, invisible infrared wave lengths.

Other types of resistance-heated elements also depend on radiation as their primary means of heat transfer. But the infrared lamp, using a tungsten filament protected by a sealed-in atmosphere of inert gas, operates at a much higher temperature than these other resistance heaters. The infrared lamp thus occupies a unique position among resistance-heating devices, since the power radiated by a source increases as the fourth power of the absolute temperature. For example, an infrared lamp operating at 2,500 deg. K. radiates 81 times as much energy as a resistance heater of the same wattage operated at one-third the absolute temperature of the lamp.

Another advantage of infrared lamps is the ease with which they can be installed. This sometimes leads the user to build what may appear to be an acceptable installation, yet which in many respects may be inadequate and uneconomical. Design of a sizable infrared oven deserves the attention of an expert.

Like other types of lamps, those used for infrared heating are subject to mechanical breakage and can also break on contact with water, paint or other liquids. Breakage of lamps due to contact with material passing through an oven on a conveyor may be averted by use of a permanent coarse-mesh screen placed between lamp banks and material. Breakage due to contact with liquids can be prevented by proper design of the oven wherein no lamps are located under the material being heated.

Infrared lamps find their chief use in the low to moderate temperature field, such as the drying of sheet and granular materials and the baking of surface finishes. In the latter application, the energy passing through the film is partially absorbed, the rest passing through is absorbed by the underlying base material, increasing its temperature; as a result, the finish bakes "from the inside out." Granular materials are most readily dried by spreading them out in a thin layer.

In continuous drying or baking ovens the lamps are arranged in suitable banks so that preferably all surfaces of objects passing through the oven are subjected to direct radiation from the lamps. The lamps are of two general types, one used with separate gold-plated reflectors, the other with the reflector sealed in the bulb itself. Typical large installations employ hundreds of lamps each rated at 125 to 1,000 watts.

In many instances infrared lamps can be used in much smaller numbers for safe and convenient spot- or batch-heating jobs. For example, in joining materials with a thermosetting cement, a single lamp usually can provide sufficient heat to cure the resin.

ARC HEATING

Whenever an electric circuit consisting of solid (or liquid) conductors is broken by an air gap, current will continue to flow if either the voltage

is high enough to ionize the gas molecules in the gap or the current is high enough to vaporize some of the conductor and fill the gap with a conducting vapor path. The latter phenomenon is the basis for arc heating.

In practice, the arc is established by bringing into momentary contact two electrodes (or one electrode and the work) and subsequently separating them. As they are being separated the last points of contact offer enough resistance to generate localized hot spots and vaporize some of the electrode material. As the electrodes are separated completely the vapor provides a conducting path of high resistance.

The limiting distance between the electrodes and, therefore, the maximum resistance of the arc, is a function of the electrode material and the voltage. Remembering, however, that the amount of heat generated depends on the I^2R loss, it is usually preferable to operate with shorter arcs and high currents rather than longer arcs and lower currents. Arc furnaces, therefore, usually operate in the range of 40 to 260 volts, electrode to shell.

The most suitable electrode materials are carbon and graphite. Graphite has a higher current-carrying capacity than carbon, but costs more per lb., so that there is actually very little real cost difference between the two materials. Consumption of electrodes is the result of oxidation, either from atmospheric air entering the furnace or from reaction with the furnace charge.

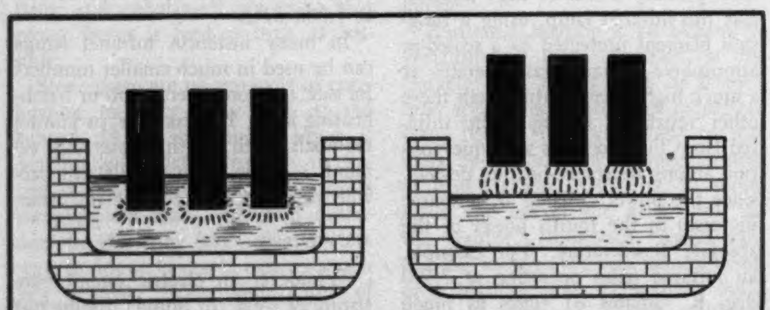
The carbon arc is the most intense source of heat used commonly in industrial practice. Its temperature is estimated at about 6,000 deg. F. The major problem of furnace designers, therefore, is to provide for the absorption of heat fast enough to keep the furnace shell and lining from getting too hot.

Circuit arrangements used in arc furnaces vary widely. Small-scale operations may use single-phase current; large commercial furnaces, however, customarily operate on a three-phase circuit. Special transformers provide two desirable features—a high reactance to even out wide fluctuations in load, and voltage-changing taps to permit using the voltage best suited to the particular operation.

The arc may be formed between the electrodes in the furnace space above the charge. The charge is heated, in such cases, by direct radiation from the arc and by reradiation from the roof and walls. When the charge itself is conducting, the arc may pass from one electrode to the charge and through the charge to a ground electrode or to another arcing electrode. With this arrangement, some heat is liberated in the charge itself by straight resistance heating. In some arc-furnace operations, the electrodes are submerged in the charge, so that resistance heating is actually the predominating mechanism, with arcing occurring only to a minor extent where the contact between electrodes and charge was poor.

Although arc furnaces are used to the greatest extent in the melting of metals and the production of ferroalloys, they figure prominently in chemical operations requiring high temperatures, such as calcium carbide and elemental phosphorus. Sizes up to 30,000 kw. are in service in this country.

Operation of arc furnaces requires closer attention than other types of electric furnaces, chiefly to adjust the position of the electrodes. Modern furnaces equipped with regulators provide this control by automatically positioning the electrodes to maintain constant current, voltage, or power consumption.



SUBMERGED arc, left, and open or radiating arc, right.

INDUCTION HEATING

Whenever an electrical conductor intercepts a changing magnetic field, a current is induced in the conducting material; the resultant I^2R loss causes heat to be generated within the material. This process is induction heating.

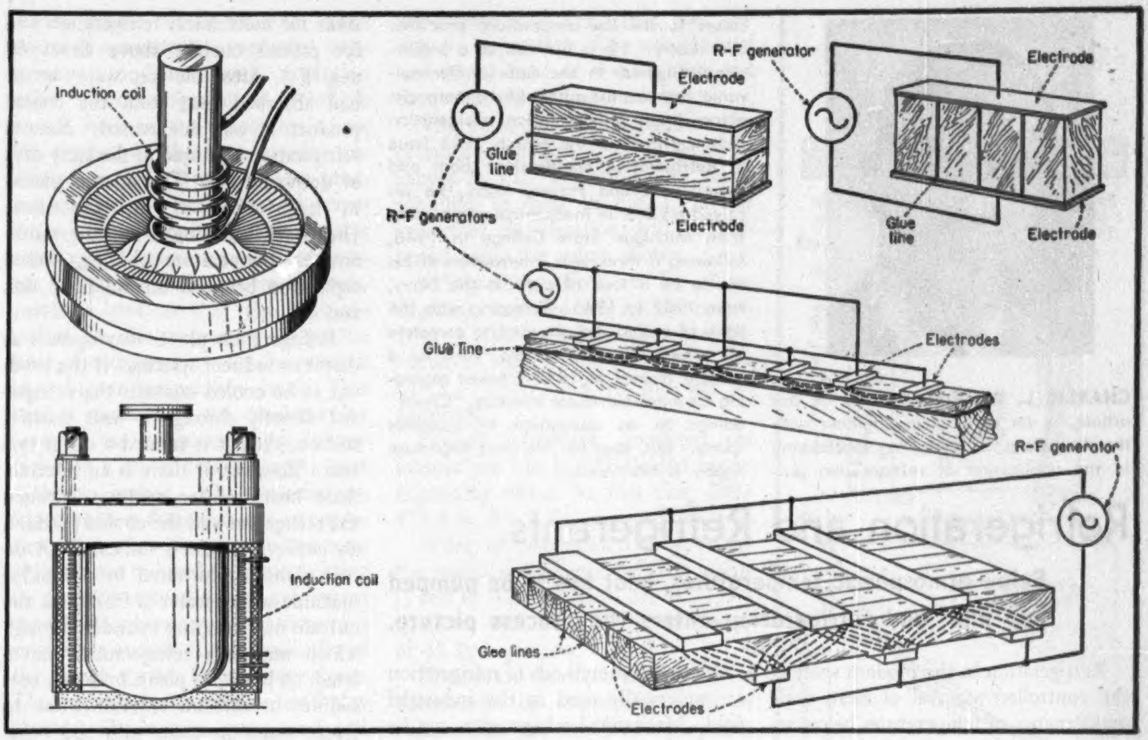
In practice the field is provided by passing an alternating current of a suitable frequency through a coil. The material to be heated is placed in close proximity to or within the coil.

Metals and other good conductors can often be heated advantageously by induction heating. Among the factors in its favor are: Heat is generated directly in the material without physical contact; heating can be concentrated in the specific areas requiring heat; the high power densities possible allow more rapid heating by induction than by other conventional methods; heating starts instantly in the work when power is applied to the coil and stops instantly when power is interrupted.

Frequencies used for induction heating cover a very wide range. As the frequency is increased, the depth of current penetration decreases. For example, at 60 cycles per sec., the effective depth of current penetration in hot steel is about 2.5 in., while at 450,000 cycles it is only 0.035 in.

The heat pattern desired and the size of the work determine the correct frequency to be used. The nominal power-line frequency of 60 cycles per sec. is used for through heating heavy sections of ferrous and non-ferrous materials or for melting. Higher frequencies up to 12,000 cycles are supplied by motor-generator sets or discharge-gap oscillators and are used for melting, through heating and thick case-hardening. Still higher frequencies, up to 500,000 cycles, referred to as radio frequencies (RF), are produced by vacuum-tube oscillators or spark-gap oscillators and are used for through heating of thinner sections and thin case-hardening.

The only limitation as to temperature attainable is the ability of the work (or the crucible in the case of melting) to withstand the temperature. The coil which carries the current is normally made of hollow copper through which water passes to



INDUCTION heating examples, left; dielectric heating for curing wood glues, right.

keep it cool, since currents of 15,000 amp. through an induction heating coil are not uncommon.

Induction heating is inherently a low power-factor process compared with resistance heating, and as the frequency is increased the conversion efficiency decreases. Although this would appear to make its use uneconomical, the reverse is usually true, since the energy from the coil is used only to heat the work in the places requiring heat. For example, to case-harden a 1-in. round piece of steel to a depth of 0.035 in. requires heating approximately 0.050 in. of the surface to 1,600 deg. F. With the power densities available, this could be done in less than 1 sec. and with one-tenth the power required to bring the whole piece up to temperature as required by slower heating methods.

Quite often less expensive materials can be used and extra operations, such as carburizing, can be eliminated. In addition, the short heating times possible with high power densities reduce scaling and oxidation to a minimum.

DIELECTRIC HEATING

Whereas induction heating is applied to electrical conductors, dielectric heating is used to heat electrical nonconductors. Electrical nonconductors are also notoriously poor conductors of heat; however, the usual heat-flow equations and problems are eliminated by the use of dielectric heating.

This is accomplished by placing the nonconductor between two electrodes or plates in a kind of sandwich and applying a voltage between the plates at a frequency in the megacycle range. This creates a rapidly alternating electric field across the material and results in a stressing of each molecular structure in the field. This stressing causes molecular friction and the result is heat. If the material is homogeneous, the voltage stress is uniform across the material, and the temperature rises uniformly throughout the material, since heat is being generated by stressing each individual molecule.

An attractive feature of dielectric heating is that heat can be generated within a material in only a fraction of the time it would take if heated by thermal conduction from the outside in. Also, temperature gradients which are required when heating from the outside can sometimes harm the hotter outside section of the material. These are not present with dielectric heating.

Selective heating can be accomplished when nonhomogeneous materials are heated, since one phase can be brought up to the desired temperature without getting the entire piece up to that temperature.

The development of urea-resin glues, whose curing is accelerated by heat, has led to the extensive use of dielectric heating in gluing wood. Here the selective feature of nonhomogeneous materials being heated is used efficiently to put most of the power into the glue rather than the wood.

Other typical uses of dielectric heating are the twist setting of rayon and nylon, preheating of plastic preforms prior to molding, sealing plastic sheets, curing and drying of cellulose sponges and foam rubber.

Although moisture evaporation is usually not an economical application for electric heating, other considerations, such as damage to the material by excessive surface temperatures and long heating times, make the use of dielectric heating quite practical. There are installations today supplying 500 kw. output of dielectric heating energy into individual ovens.

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Refrigeration and Refrigerants

Below atmospheric temperatures, heat has to be pumped "up hill" and refrigeration enters the process picture.

Refrigeration in the modern sense is the controlled removal of heat, with maintenance of temperatures below atmospheric conditions. Chemical engineers have applied refrigeration for many purposes including the following: gas separation at low temperatures; condensation of gases; dehumidification of air; solidification of a solute in a solvent; low-pressure liquid storage; removal of heat of reaction; recovery of solvents; control of fermenting temperatures; sublimation or freeze drying of heat-sensitive substances; cooling for preservation, and other cooling applications. Table I lists a few specific applications of refrigeration in the chemical field, along with the applicable temperature levels.

Mechanical methods of refrigeration are universally used in the industrial field. Mechanical refrigeration can be defined as the removal of heat by the expenditure of mechanical (or heat) energy. Vapor-compression, steam-jet and absorption refrigeration, and the heat pump are various methods of mechanical refrigeration. These systems all have the characteristic of recirculating the refrigerant in a closed circuit.

Natural refrigeration methods are nearly obsolete today but were quite prevalent around the turn of the century. Natural methods include use of natural ice, ground water and the placing of the product in cold atmospheric air. (But ground and surface water, and atmospheric air, are used as heat sinks for mechanical refrigeration and for process cooling above about 60 deg. F.) After the ice, water or air had absorbed heat from the cooled product it was not reused. Natural refrigeration was used in the early days of dewaxing oils. The oil was placed in large tanks in the wintertime (hence "winterizing") and the resultant low-temperature chilling caused separation between the solidified wax and oil.

Refrigeration plants may operate as direct or indirect systems. If the product to be cooled contacts the refrigerant directly through a heat transfer surface, then it is termed a direct system. However, if there is an intermediate heat transfer medium between the refrigerant and the cooled product, an indirect system is indicated. A direct plant is illustrated by a FlakIce machine where water is frozen on the outside of a rotating cylinder through which ammonia refrigerant is circulated. A block-ice plant, however, uses sodium or calcium chloride brine to freeze water in cans, with the brine heat transfer medium cooled by an ammonia evaporator. Many process cooling systems are of this type. This is termed an indirect system.

The unit of refrigeration is the ton, a rate unit. A ton of refrigeration is the heat necessary to melt 2,000 lb. of 32 deg. F. ice to 32 deg. F. water in 24 hr. Since the latent heat of fusion for ice is 144 Btu. per lb., this means 288,000 Btu. per day, 12,000 Btu. per hr., or 200 Btu. per min.

VAPOR COMPRESSION SYSTEMS

Most industrial refrigeration plants use the vapor-compression system.

Table I—Typical Refrigeration Applications in the Chemical Process Industries

Process	Product or Equipment	Temperature Level, Deg. F.
Gas separation	High-purity and tonnage oxygen	−280 to −180
	Hydrocarbons	−250 to −150
Condense gases	Chlorine	−80 to +20
	Anhydrous hydrofluoric acid	−90 to +40
	Synthetic ammonia	0 to +50
Dehumidification of air	High-purity and tonnage oxygen	−60 to 0
	Nitric acid	−10 to +30
	Material assembly	+40 to +70
	Ozone	+40
	Pharmaceuticals	+50 to +70
Solidify solute from solvent	Dewaxed oil	−15
	Sodium nitrate	+40
	Potassium chlorate	−15
	Sodium sulfate	+25
	Ammonium nitrate	+40
Low pressure liquid gas storage	Natural gas	−250
	Ammonia	+40
Process cooling	Harden wax on paper	+10 to +50
	Cool rubber mixers	+40
Remove heat of reaction	Viscose rayon	+38
	Camphor	+50
	Cellulose acetate	+40
	Cold rubber	+40
	Dyes (nitration processes)	+40
	Nitrocellulose	+50
	Amine acetate	−60
Recover solvents	Film (acetone)	−80 to +20
	Textiles (carbon tetrachloride)	+30
	Rubber (carbon disulfide)	+30
	Rayon (acetone)	+40
Control fermenting temperatures	Alcohol	+45
	Penicillin	+40 to +50
Sublimation, freeze drying	Blood plasma	−70 to 0
	Antibiotics	0
Cooling for preservation	Natural rubber	+60
	Drugs	+40
	Explosives	+50

These plants consist of four major pieces of equipment—evaporator, compressor, condenser and expansion valve. The refrigerant, as a volatile liquid, boils in the evaporator where the product or the heat transfer medium is cooled. Heat from the product supplies the latent heat of evaporation to the refrigerant. A compressor removes the vapors from the evaporator, increasing their pressure and temperature level so that the heat absorbed in the evaporator—plus the heat of compression—can be rejected at a higher temperature level. This heat is removed in the condenser by bringing the refrigerant vapor in contact with a cooler fluid through a heat exchange surface. The liquefied refrigerant then flows through an expansion valve where its pressure and temperature are reduced to those existing in the evaporator. As the refrigerant expands to a lower pressure, some of it evaporates and cools the remainder of the liquid to the lower temperature. This expansion is a constant-enthalpy process. Single-stage, compound and cascade systems are three methods of vapor compression in use, and all will be described.

SINGLE-STAGE VAPOR COMPRESSION

The single-stage vapor-compression system is so designated because the refrigerant vapor is compressed in a single stroke of a piston. A sketch of such a plant is shown in Fig. 1, with the ideal temperatures and pressures for ammonia refrigerant indicated at the various points. In this sketch the brine heat transfer medium flows through the evaporator where it is cooled from +20 to +15 deg. F. The refrigerant is at a lower temperature (+5 deg.) than the brine and heat flow to it causes the refrigerant to boil. The vapor is taken into a compressor where the pressure and temperature are increased to 154.5 psig. and 210 deg. F., respectively. The sensible heat and latent heat of condensation are then removed in the condenser.

This cycle can be illustrated on the pressure -enthalpy (P–H) diagram as shown in Fig. 2, with values corresponding to those in Fig. 1. A few important considerations will be illustrated using the values shown.

Refrigerating effect per lb. of refrigerant circulated through the evaporator is the enthalpy difference between D and B. That is, $H_B - H_D$ = 613.3 − 138.9 = 474.4 Btu. per lb. ammonia.

Pounds refrigerant circulated per minute per ton is 200 divided by refrigerating effect; in this case 200/474.4 = 0.422 lb. ammonia per ton.

Work of compression is given by the enthalpy difference between points C and B. That is, $H_C - H_B$ = 713 − 613.3 = 99.7 Btu. per lb. ammonia, or 42 Btu. per ton.

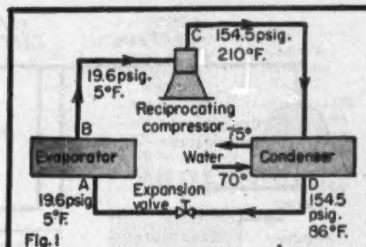
Theoretical horsepower per ton is determined by converting work of compression per ton into horsepower by use of the conversion factor 42.42 Btu. per min. = 1 hp. Here 42/42.42 = 0.988 hp. per ton.

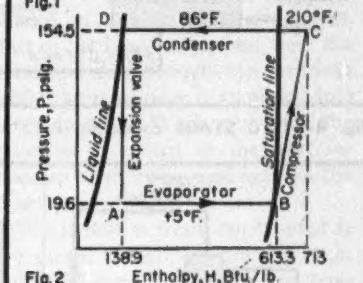
Heat rejected in the condenser is $H_C - H_D$ or 713 − 138.9 = 574.1 Btu. per lb. ammonia, which amounts to 242 Btu. per ton.

Coefficient of performance CP is the ratio of refrigerating effect to work of compression. Here CP = 474.4/99.7 = 4.76.

Compression ratio CR is the absolute discharge pressure, divided by the absolute suction pressure. Here CR = (154.5 + 14.7)/(19.6 + 14.7) = 4.94.

The power requirements in an actual plant are greater than the theoretical horsepower due to compressor inefficiencies and design. For this case the actual horsepower per ton would be approximately 1.3. Typical horsepower requirements for two refrigerants used in simple vapor-compression systems are shown in Fig. 3. It will be noted that as the evaporator temperature decreases, which is an indication of higher compression ratios, the horsepower increases. The compression ratio is generally limited





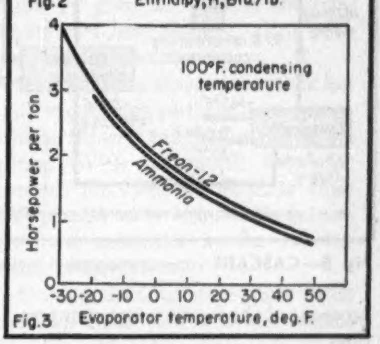


Fig. 1—SINGLE-STAGE ammonia vapor-compression system.

Fig. 2—P-H DIAGRAM for Fig. 1.

Fig. 3—TYPICAL power requirements for simple vapor-compression system.

Table II—Characteristics and Application Range of Common Industrial Refrigerants

Refrigerant	Chemical Symbol	Mole Wt.	Standard Rating Conditions: Evap. Press. @ 5° F., Psia.	Cond. Press. @ 86° F., Psia.	Compr. Ratio	Refrigerant Circulated Per (Min., Ton): Lb.	Ft.³ Gas	Theor. Hp. per Ton	Coef. of Performance	Econ. Evap. Temp. Range, °F.: Single-Stage	Multi-Stage	Type Compr.*
Ammonia.......	NH_3	17.03	34.3	169.2	4.94	0.422	3.46	0.98	4.75	−30 to 50	−90 to 20	A, B, C
Butane.........	C_4H_{10}	58.12	8.2	41.6	5.01	1.62	16.16	1.01	4.67	−20 to 50	−60 to 50	A, B, C
Freon-11.......	CCl_3F	137.38	2.92	18.3	6.24	2.96	36.3	0.94	5.0	None	−20 to 50	C
Freon-12.......	CCl_2F_2	120.9	26.51	107.9	4.08	3.91	5.81	1.00	4.69	−30 to 50	−125 to 50	A, B, C
Freon-22.......	$CHClF_2$	86.48	43.02	174.5	4.06	2.89	3.60	1.01	4.65	−40 to 50	−125 to 10	A, B
Freon-113	$C_2Cl_3F_3$	187.33	0.98	7.8	8.02	3.73	100.9	0.98	4.84	None	−25 to 50	C
Freon-114......	$C_2Cl_2F_4$	170.93	6.77	36.7	5.42	4.64	19.59	0.99	4.74	None	−25 to 50	C
Methyl chloride.	CH_3Cl	50.48	21.15	94.7	4.48	1.33	5.95	1.02	4.62	−20 to 50	−80 to 20	A
Propane........	C_3H_8	44.06	41.9	155.2	3.70	1.65	4.09	1.02	4.62	−40 to 50	−125 to 50	A, B, C
Propylene......	C_3H_6	42.05	51.7	181.7	4.95	1.60	3.34	1.06	4.46	−40 to 50	−125 to 50	A, B, C
Sulfur dioxide...	SO_2	64.06	11.8	66.5	5.63	1.40	9.10	0.97	4.86	−10 to 50	−60 to 50	A

* A, reciprocating; B, rotary; C, centrifugal.

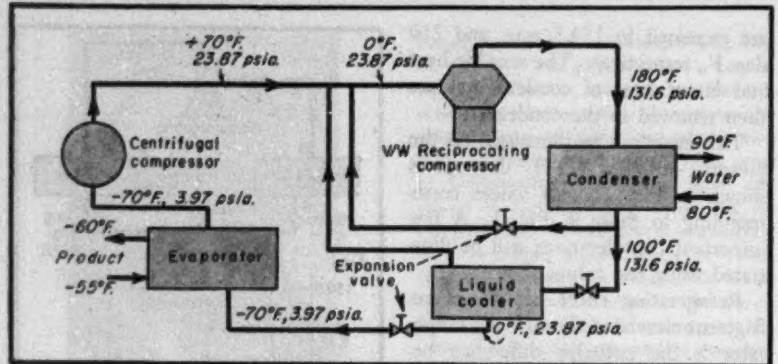


Fig. 4—TWO STAGE compound F-12 vapor-compression refrigeration cycle.

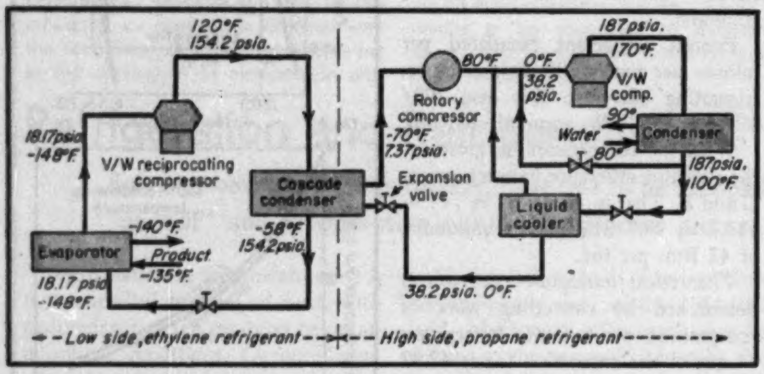


Fig. 5—CASCADE vapor-compression system uses different refrigerants in two stages.

because of high discharge temperatures.

The single vapor-compression cycle accounts for a great majority of all systems under 300 tons and operating down to around −20 deg. F.

Table II gives a comparison of some of the refrigerants used in single-stage plants, along with the economical operating limits.

COMPOUND VAPOR COMPRESSION

The compound or multi-stage vapor compression system is used to obtain lower temperatures than can be economically obtained with a single-stage system. Compound plants are so designated because the refrigerant vapor is compressed in several stages from the evaporator to condenser. Compression of the vapor can be handled by separate compressors on each stage or by one compressor with the vapor flow through several stages in series within the compressor. The centrifugal compressor generally has two or more compression stages.

Fig. 4 shows a two-stage compound compression system, with typical operating values for Freon-12 as the refrigerant, using a four-stage centrifugal compressor and a single-stage reciprocating compressor. Freon-12 vapor is taken from the evaporator at −70 deg. and compressed to 23.87 psia. intermediate pressure, which corresponds to a saturation temperature of 0 deg. F. The discharge temperature from this compressor is 70 deg. F. This vapor is cooled to the saturation temperature of 0 deg. F. by expanding liquid from the condenser into this vapor line. The vapor from the liquid intercooler which was used for subcooling the refrigerant supplied to the evaporator is also added to this vapor line. All of the vapor entering at the intermediate pressure is compressed in the second-stage compressor up to condensing pressure. Liquid refrigerant from the condenser is taken through an intercooler where it is cooled to the intermediate temperature, and this subcooling results in a thermodynamic gain in the system as each pound of refrigerant circulated through the evaporator is capable of taking more heat from the cooled product.

The size of compressors available for compound plants sets the intermediate pressures, but for most economical equipment selection and operating cost, the compression ratios of the stages should be nearly equal.

Two-stage plants can usually be justified on the basis of reduced operating expense and first cost of equipment from around −20 deg. F. evaporator temperature, down to about −80 deg. F. If a centrifugal compressor were used over this same range, from six to eight stages would be required. Three-stage compression plants are used below −80 deg. F. and down to −135 deg. F. with the proper refrigerant. Table II gives the operating range of refrigerants used in compound plants.

CASCADE VAPOR COMPRESSION

Cascade vapor-compression systems have been used for the temperature range from −250 deg. F. to −100 deg. F. They consist of two or more independent single or compound compression systems using different refrigerants. Fig. 5 shows a cascade system with a single stage of ethylene vapor compression on the low-temperature side and two stages of propane vapor compression on the high-temperature side. The discharge gas from the ethylene compressor is condensed in the cascade condenser by the evaporation of propane. The evaporator of the high-stage system, in this case the propane system, becomes the condenser for the low-stage system.

There are two interrelated reasons for using a cascade system. First, the refrigerants used in the low stage have critical pressures at temperatures below that obtainable in a water-cooled condenser, hence requiring condensation at a lower temperature. Second, most of the readily available refrigeration equipment is designed for around 250 psig. maximum pressure which becomes a limit for discharge pressures.

By use of a cascade system it is possible to choose the various refrigerants at their most economical operating point, which means low compression ratio, low hp. per ton, low cfm. per ton and moderate working pressures.

In comparison to the ethylene-propane system shown in Fig. 4, if Freon-22 were used in the evaporator at −148 deg. F., the cfm. per ton would be 250, while ethylene requires 8. This shows up as a considerable first-cost saving in compressor size, piping, insulation for piping, etc.

The cascade system requires an overlap of temperatures in the cascade con-

Table III—Characteristics and Application Range of High-Pressure Refrigerants

Refrigerant	Chemical Symbol	Mole Wt.	Evap. Temp. @ 40 Psia., °F.	Cond. Temp. @ 200 Psia., °F.	Refrigerant Circulated Per (Min., Ton) Lb.	Refrigerant Circulated Per (Min., Ton) Ft.³ Gas	Theor. Hp. per Ton	Coef. of Performance	Temp. Range, °F. Evaporator Temp.	Temp. Range, °F. Cascade Condenser Temp.
Methane	CH_4	16.03	−234	−178	1.27	4.40	1.46	3.23	−275 to −215	−205 to −170
Freon-14	CF_4	88.0	−170	−106	5.41	4.43	1.28	3.70	−250 to −150	−135 to −95
Ethylene	C_2H_4	28.03	−111	− 43	1.40	4.06	1.39	3.40	−200 to − 90	− 70 to −10
Ethane	C_2H_6	30.04	−90	−7	1.40	4.27	1.35	3.49	−190 to − 60	− 35 to +10
Freon-13	$CClF_3$	104.4	−77	+8	5.03	4.65	1.46	3.23	−200 to − 50	− 30 to +20
Carbon dioxide	CO_2	44.0	−69.9*	− 24	1.56	1.81	0.61	7.85	− 69 to − 40	− 20 to +50

* Triple point pressure, 75.1 psia.

denser which results in higher power requirement than a compound system using the same refrigerant over the same temperature range.

Some of the refrigerants commonly used in the low stage of the cascade system are methane, Freon-14, ethylene, Freon-13 and ethane. The operating range and other information on these refrigerants is given in Table III.

In the last few years cascade systems have been installed using two common refrigerants such as ammonia and Freon-12 in order to utilize the low-cost and efficient Freon centrifugal system, and evaporators more suitable for ammonia. Liquid ammonia evaporates and is taken into the cascade condenser cooled by Freon-12 at a lower temperature. In new plants the system is used when the load involved is not large enough for an ammonia centrifugal compressor. An existing ammonia plant can increase its capacity by using a cascade system in parallel with the original ammonia compression system.

AIR EXPANSION SYSTEM

Cascade systems are used down to around −250 deg. F. For further temperature reduction it is possible to use a gas such as nitrogen as the refrigerant in the low side. Another method for producing very low temperature is to use an air expansion engine or turbine. In one of these systems air is compressed to 80 psig. and dehumidified by water coils and refrigerant coils. The air is regeneratively cooled in a heat exchanger down to −250 deg. and then enters the expansion engine where work is performed. Therefore heat is removed from the air, reducing its temperature to around −290 deg. F. This cooled air supplies the necessary refrigeration and then cools the warm air in the heat exchanger. Variations of the air-expansion turbine system are used in low-temperature separations, for example, oxygen and nitrogen in high purity and tonnage oxygen plants.

ABSORPTION REFRIGERATION

Absorption refrigeration systems use two working substances, a refrigerant and an absorbent. One of the more frequent combinations is ammonia-water, usually referred to as an ammonia absorption system. It can be used over a wide range of evaporator temperature, and the sizes range from 150 to 5,000 tons. A diagram of one of these plants is shown in Fig. 6 with typical operating conditions of a plant for cooling calcium chloride brine. The brine is cooled in the evaporator by ammonia refrigerant and the vapor flows to the absorber. A weak solution of ammonia in water (weak aqua) is sprayed into the absorber and absorbs the ammonia thereby becoming a strong solution of ammonia in water (strong aqua). Cooling water through the tubes of the absorber removes the latent heat of condensation and the heat of association.

A pump takes the strong aqua from the absorber, which operates at evaporator pressure, and increases the pressure to generator pressure. The temperature of the strong aqua is increased in a heat exchanger before it enters the generator. Heat is applied, driving ammonia and water vapor from the strong aqua solution and forming weak aqua. The vapor passes through a bubble cap plate tower. The pure ammonia vapor from the tower is condensed in a water-cooled condenser. Part of the liquid refrigerant from the condenser is used as reflux in the tower while the remainder is expanded into the evaporator. Weak aqua from the generator is cooled in the heat exchanger before being used again in the absorber.

Waste heat or steam can be used as the source of heat for the generator. Table IV gives the quantity and temperature of heat required, along with the steam and water rate.

The ammonia absorption system has only one moving part, the aqua pump, which reduces the maintenance expense. With the proper automatic controls the load can fluctuate from 100 percent to 0 with a directly proportional reduction in the rate of steam consumption.

Outdoor installation is quite often used for these systems which makes for reduced building costs.

There are other possible combinations of refrigerant and absorbent which can be used, such as water-lithium bromide, and methylene chloride-dimethyl ether or tetraethylene glycol. The water-lithium bromide system must be used above the freezing point of water and depends on the maintenance of a high vacuum in the evaporator so that evaporating water can cool the remaining water to the desired temperature.

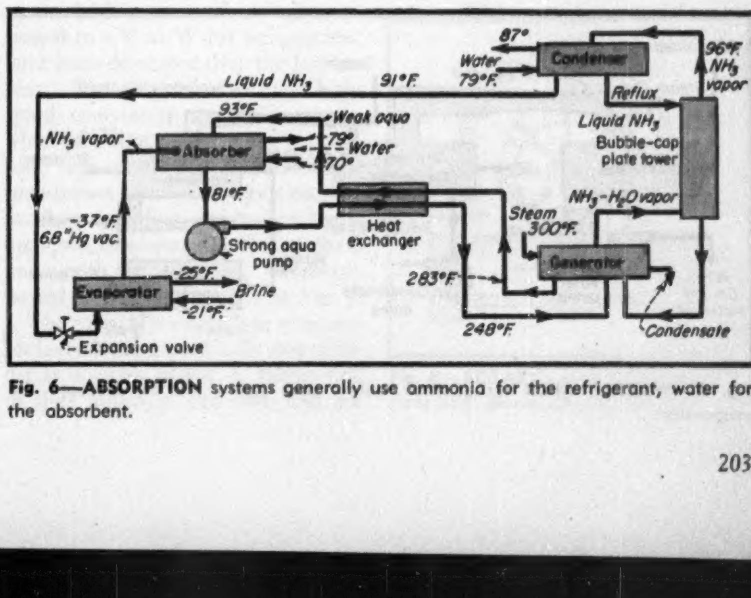


Fig. 6—ABSORPTION systems generally use ammonia for the refrigerant, water for the absorbent.

Table IV—Heating and Cooling Requirements for an Absorption Plant

Evaporator Temp., °F.	Generator Temp. Req. °F.	Btu. Req. Per (Min., Ton)	Lb. Steam Per (Hr., Ton)	85° Water, Gpm. Per Ton
+50	210	325	20.1	3.9
+40	225	353	22.0	4.0
+30	240	377	23.7	4.1
+20	255	405	25.7	4.3
+10	270	435	28.0	4.6
0	285	467	30.6	4.9
−10	300	501	33.6	5.4
−20	315	555	37.3	5.9
−30	330	621	42.5	6.6
−40	350	701	48.5	7.7
−50	370	820	57.8	9.5

Table V—Approximate Primary Booster Steam Requirements for Steam Jet Refrigeration

Initial Steam Pressure, Psig.	Chilled Water Temp., °F.	Lb. Steam per (Hr., Ton Refrig.) at Cond. Temp., °F. 90	95	100	105
100	40	23.2	27.3	32.3	38.3
	45	19.0	22.3	26.1	30.9
	50	16.0	18.7	21.8	25.3
	55	13.9	16.1	18.7	21.8
50	40	29.0	34.1	40.4	47.8
	45	23.7	27.9	32.6	38.6
	50	19.2	22.5	26.2	30.4
	55	16.0	18.5	21.5	24.1
30	40	34.8	41.0	48.5	57.5
	45	26.6	31.2	36.5	43.3
	50	20.8	24.3	28.4	32.9
	55	17.4	20.1	23.4	27.3
10	40	46.4	54.6	64.6	76.0
	45	31.4	36.8	43.1	51.0
	50	24.0	28.1	32.7	38.0
	55	18.8	21.7	25.2	29.4
2	40	58.1	68.3	80.9	95.8
	45	40.8	47.9	56.1	66.4
	50	28.0	32.7	38.2	44.3
	55	22.2	25.8	29.9	34.9

STEAM JET REFRIGERATION

Steam jet refrigeration makes use of the principle that if heat is not supplied from an external source during evaporation of a liquid, then the body of liquid will fall in temperature to supply the necessary heat of evaporation. Using this principle a body of water can be cooled by evaporation of a small percentage of the water. Fig. 7 is a diagram of a steam jet system with operating conditions for producing 40 deg. F. chilled water. The steam jet system, in comparison to other systems using a refrigerant such as ammonia or Freon, would use water as the refrigerant.

The warmer return water is sprayed into an evaporator which is held at a high vacuum. Some of the water flashes into vapor and the remainder is cooled to the temperature corresponding to the absolute pressure of the evaporator.

Steam is expanded in the primary booster ejector. As it expands at a high velocity it entrains and compresses the flashed water vapor from the evaporator. The vapor is compressed up to a point where it can be condensed with cooling water in the primary condenser. A condensate pump may be used to remove condensate from the primary condenser.

A secondary ejector removes air and other non-condensibles (along with some water vapor) from the primary condenser and puts them through an intermediate condenser where more water vapor is condensed. Another secondary ejector purges the intermediate condenser and increases the pressure up to atmospheric pressure in the after condenser which is vented.

In the example in Fig. 7, for each pound of chilled water, 10 Btu. would be removed through the 10 deg. range. With the latent heat of 40-deg. water at 1,071 Btu. per lb., an evaporation rate of $10/1{,}071 = 0.0093$ lb. of water would be required. This amounts to 1 percent of the water being cooled.

Table V gives the steam rate per ton of refrigeration with various chilled water and condensing water temperatures, and various steam pressures.

HEAT PUMP SYSTEM

The industrial application of the heat pump or reverse-cycle system uses a system hook-up similar to a standard single-stage vapor-compression system as shown in Fig. 1. This type of system is usually applied to industrial water cooling where there is a wintertime heating duty.

In the summer months the chilled water is cooled in the evaporator in the usual fashion, and ground or river water is used for condensing purposes. In the wintertime the water used for the condenser is put through the evaporator where it is cooled. The heat taken from the evaporator plus the heat of compression is rejected in the condenser to the warm water which can be used for a heating process.

A special form of the heat pump can be used for concentrating processes. The refrigerant condenser supplies heat to the product to accomplish vapor evaporation. The vapor is then condensed in the evaporator of the refrigeration system. A steam ejector is used to provide a vacuum so that the evaporation and condensation can take place at temperatures easily obtainable with a single-stage plant.

REFRIGERANTS

Two groups of refrigerants will be considered. One group includes the common industrial refrigerants that

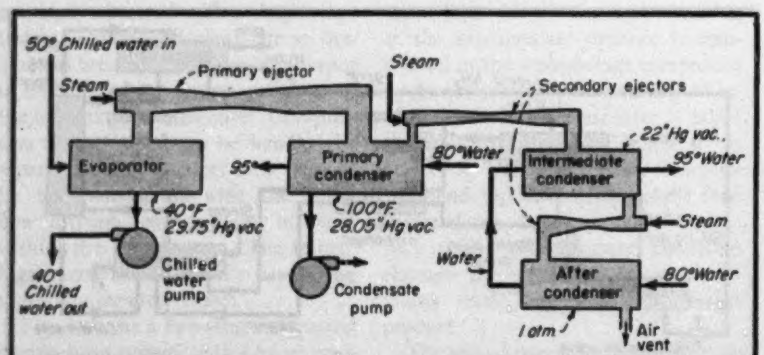


Fig. 7—WATER VAPOR refrigeration system uses steam jets to evacuate the evaporator.

can be condensed with water or air. The other includes the so-called high-pressure refrigerants that are condensed in cascade systems. Table II compares the most widely used common refrigerants at 5 deg. F. evaporating and 86 deg. F. condensing temperature.

The condensing pressure and cfm. of gas per ton of refrigeration set the size and weight of the refrigeration equipment and are important first-cost factors. Theoretical power per ton of refrigeration and coefficient of performance are indications of the plant operating efficiency. It is interesting to note that all of the power-per-ton figures are within 5 percent of the average, indicating nearly equal operating costs. As a result of this, prime consideration in selecting the refrigerant—particularly in small plants—must be given to first-cost factors such as size of compressor and safety of the refrigerant. In large plants, where a small difference in power per ton can mean considerable operating expense on a yearly basis, both first cost and operating cost must be carefully considered.

In systems with large volumes of refrigerant, the refrigerant cost becomes a major factor, especially when leakage is taken into consideration. This points up one of the reasons for the petroleum industry using hydrocarbon gases for their refrigeration requirements.

Ammonia has a low first cost, a low cfm. per ton and a high coefficient of performance, all of which are desirable. This gives some of the reasons for its popularity.

The economical evaporator temperature ranges for single- and multiple-stage plants are listed in Table II. For the refrigerants suitable only for centrifugal compressors, the ranges are indicated among the multi-stage plants as these compressors usually have at least two stages. Whether a single- or multi-stage plant is used in the overlapping temperature range depends on the size, operating expense, and first cost of the plant along with the all-important factor of space available. The types of compressors made for use with the various refrigerants are also included in the table.

Freon-11, Freon-113, and Freon-114 have been used exclusively with centrifugal compressors. These Freons along with Freon-12 are very suitable for centrifugal compression because of their high molecular weights (high vapor densities) which result in low pumping heads. This factor keeps the number of stages and operating speeds at a minimum.

Table III lists a group of the high-pressure refrigerants which have been compared at the temperature levels corresponding to a pressure of 40 psia. in the evaporator and 200 psia. in the condenser. The cfm. per ton for these refrigerants is nearly the same, with the exception of carbon dioxide which is at a higher evaporator pressure due to its triple point being at 75.1 psia.

The range of temperatures for the evaporator and cascade condenser are indicated in Table III and have been set so standard compressors could be used. In general, reciprocating and rotary compressors are in use on cascade systems with these refrigerants, as the sizes have not often justified centrifugals.

Heavy-duty equipment has been available for carbon dioxide plants. However, owing to the high pressures involved these systems are gradually being replaced by plants using a lower pressure refrigerant.

COMPRESSORS

Reciprocating, rotary and centrifugal refrigerant compressors are all in general use.

Reciprocating compressors have one or more pistons to compress the gas. Various cylinder arrangements, numbers of cylinders, etc., are available.

Vertical and horizontal reciprocating compressors have large displacements per revolution and slow operating speeds, below 400 rpm. Foundation and floor area requirements are large for these compressors.

High-speed compressors operating up to 1,800 rpm., with cylinders arranged in a V or W for compactness, have been developed over the last ten years. The advantages of the high-speed compressor are many, among which are direct connection to low-cost, high-speed motors, light-weight foundations, minimum vibration, upper floor mounting, and smaller building space requirements. One of these units with 16 cylinders, direct-connected to a motor, appears in Fig. 9.

The rotor of a rotary type compressor is mounted eccentrically in a cylinder as is shown in Fig. 8. Blades ride in slots milled in the rotor and are forced out to the cylinder wall by centrifugal force. The gas is drawn into the compressor between a pair of blades and rotation of the rotor causes compression as the blades are forced into the rotor slots. Such compressors are used in compound plants on the low stage for large displacement and low pressure differential.

Fig. 10 shows a high-speed centrifugal compressor which is generally used at capacities above 200 tons. Rotor speeds from 3,000 to 9,000 rpm. give a large cfm. displacement, with very small space requirement.

Impellers, keyed to the rotor shaft, are made up of two disks with vanes between them. Gas flows from the eye of the impeller to the outer edge, then being directed into the eye of the next impeller. The number of impellers in a single housing varies from two for a water cooling system, to four for a −40 deg. cooling load using one of the Freons as a refrigerant.

In low first cost, a centrifugal system competes with a reciprocating installation between 200 and 300 tons, at the water cooling level. In choosing the type of compressor to use the major points to investigate are: percent capacity at which plant will run during the off season; variation in operating conditions from the design point; type of drive to be used; and overall first cost, operating cost and maintenance.

CONDENSERS AND EVAPORATORS

Refrigerant condensers can be cooled by water, air or evaporating water. Water-cooled condensers are of the shell-and-tube type, with the water in plain or finned tubes. Finned tubes give more surface in a given volume, resulting in smaller space requirements.

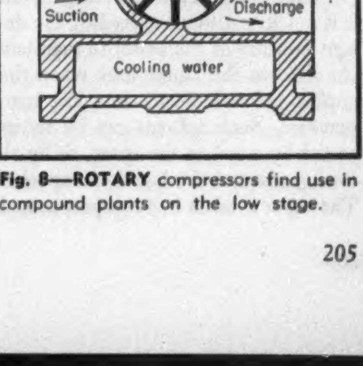


Fig. 8—ROTARY compressors find use in compound plants on the low stage.

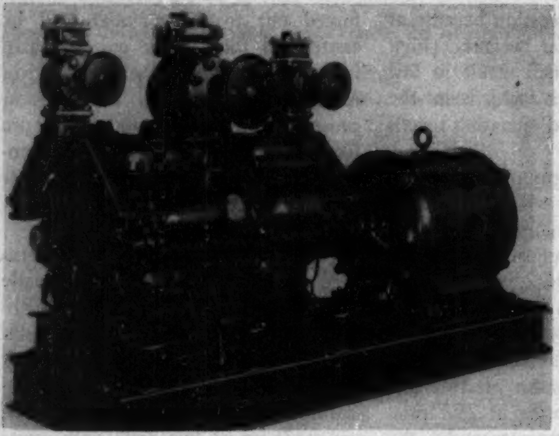


Fig. 9—RECIPROCATING compressor with 16 cylinders in W arrangement uses direct motor drive.

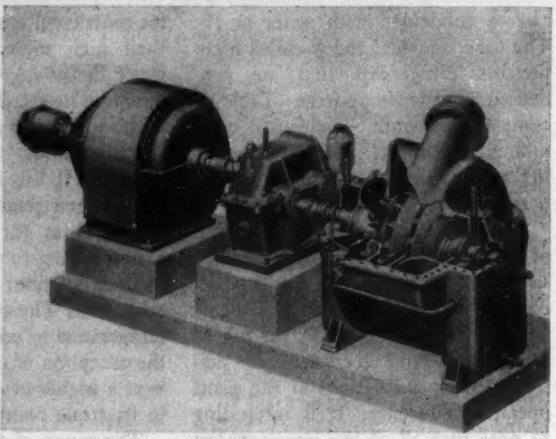


Fig. 10—CENTRIFUGAL compressors are used mainly for capacities above about 200 tons.

Evaporative condensers are cooled by water evaporating into an air stream over a coil. This removes the heat of condensation from the refrigerant flowing inside the coil.

Evaporative and ordinary water-cooled condensers are both used for systems with capacities up to about 200 tons; the latter system is used above this tonnage.

A stream of air flowing across finned tubes is used in air-cooled condensers which find their application in small systems such as home refrigerators and packaged air conditioners, or where water is unavailable.

There are many types of evaporators depending upon the form and temperature of the product being cooled. Horizontal or vertical shell-and-tube and plate exchangers, submerged coils in tanks, with or without agitation, and finned coils, are a few of the main types.

Thermal, hand- or float-operated expansion valves are some of the ways of controlling refrigerant flow to the evaporators. Controls such as room thermostats, low- and high-pressure cutouts and suction-pressure regulators help to make systems automatic.

A FEW PROCESSES

Storage Spheres—Refrigerated storage of volatile liquids has been used for some time. Through refrigeration it is possible without exceeding the design pressure of the vessel to maintain the fluid in the liquid state when the critical pressure occurs at a low temperature. Such spheres can be refrigerated by a coil in the space, or by allowing some of the liquid to vaporize. The vapor is taken to a compressor and condenser and expanded back into the sphere.

A method of storing liquefied natural gas used some years ago in Cleveland was to take the properly dehumidified gas and cool it down to about −125 deg. F. at 600 psig. The gas then expanded to a lower pressure so that part of it liquefied, flash gas being recycled through the compressor to be re-expanded. The liquid was again expanded to a lower pressure so that the storage sphere could operate at a pressure of around 10 psig. The natural gas was maintained at around −260 deg. F. by evaporation, the vaporized gas being recompressed, recondensed and expanded back into the liquid storage. Initial cooling made use of a cascade refrigeration system with ethylene in the evaporator to cool the natural gas, and ammonia in the high stage to condense the ethylene. The system has not been used since a disastrous fire caused by brittle failure of the steel in one of the storage spheres.

Refrigerated spheres have also been used for ammonia storage at pressures from 0 to 70 psi. Ammonia evaporates in the sphere and is recompressed to a pressure where it can be condensed with water; it is then expanded back into the sphere.

Synthetic Ammonia Plants—Refrigeration has been extensively used in the manufacture of synthetic ammonia. In some of the processes an ammoniacal cuprous solution is used to absorb the last traces of carbon monoxide from the gas stream ahead of the synthesis step. Steam is used to drive the CO from the solution and it is then cooled with water and ammonia down to +15 deg. F. to increase its absorbing efficiency. After the synthesis process part of the ammonia is condensed from the gas stream using water, while the remainder is condensed in an ammonia-cooled condenser at 0 deg. F.

Chlorine Production—Chlorine cannot be economically compressed for liquefaction at normal condensing temperatures with water because of its corrosive nature. Chlorine from the cells is compressed to 25 to 50 psi. in a sulfuric-acid-sealed pump. With inert gases present, this vapor starts to condense around 20 deg. F. A primary chlorine condenser removes most of the chlorine at temperatures of −40 deg. F. to +10 deg. F. However, to remove nearly all of the chlorine from the gas stream, a secondary condenser is used, operating at from −90 deg. to −50 deg. F. This type of plant is ideal for a compound hookup. One recent installation for 350 tons of chlorine per day used a Freon-12 rotary compressor on the secondary condenser at −80 deg., pumping into a four-stage Freon-12 centrifugal compressor at −40 deg. F. evaporator temperature on the primary condenser.

Oil Dewaxing—Refrigeration has been used for many years in the oil refining industry for dewaxing. Cold settling, wax distillate settling, centrifuge dewaxing with naphtha, and solvent dewaxing with methyl ethyl ketone or propane are some of the methods used.

In the wax distillate settling, the oil to be dewaxed is cooled in ammonia-cooled, scraper-type, double-pipe heat exchangers to a temperature below the desired pour point. It is then filtered to remove the wax. Propane dewaxing

systems use propane as the solvent and as this is a very suitable refrigerant, self-refrigeration of the solution is accomplished. After proper mixing of the propane and oil at a pressure of 200 psi., some of the propane is allowed to evaporate, cooling the remainder. The evaporated propane is compressed, the heat is rejected to a water-cooled condenser, and liquid propane is expanded back into the cooling chamber.

Self-refrigeration is an economical process here since the compressor pumps from -10 deg. to condensing temperature, rather than from -20 or -30 deg. F. for a process using an oil chiller. Another important factor is that the propane system does not require an evaporator.

Freeze Drying—Freeze drying is used for such processes as producing blood plasma from whole blood. The whole blood is placed in a refrigerated space and a vacuum pump decreases the pressure. Water is evaporated and the remaining blood supplies the heat for vaporization. This reduces the temperature very quickly and freezes the remaining blood. Sublimation of the remaining water vapor is carried out at temperatures down to -90 deg. F. A refrigerant-cooled vapor condenser between the drying chamber and the vacuum pump reduces the volume of vapor to be handled by the pump and also reduces contamination of the oil in the pump. A similar process has also been used in manufacturing antibiotics.

Dehumidification of Air—Dehumidification of air is used in drug and explosives manufacturing, to prevent hygroscopic material from absorbing moisture. In the drug industry it is used to aid in coating pills, in capsule assembly rooms and also to control quality of other items such as glandular products. Dehumidification is also used to a lesser extent for employee comfort. It is used in precision assembly work to prevent oxidation, and finds extensive application in film manufacturing and storage.

ICE IN PROCESS WORK

Ice can be a very useful material in chemical processing to remove heat of reaction and to accomplish process cooling. It is particularly valuable in batch processes where large quantities of refrigeration are required in short periods of time. Ice can be added directly to the process if the presence of water is not harmful, or it can be used to cool water for circulation through jackets.

There are essentially two types of ice manufactured, can or block ice, and ice fragments, such as flake ice. The first cost of equipment for the two types of plant is comparable but the operating expense and space requirements for the FlakIce system is less. Thus the overall cost of the latter system is less than the block-ice plant. Small-ice plants can be installed at the point where ice is needed, usually above the process so that the ice can flow by gravity to the point of use. However, block-ice plants are normally restricted to the ground floor, owing to the heavy weight involved. When flake ice is used as an addition to a process, its thin flakes melt rapidly and transfer their refrigeration quickly. Block ice, however, needs to be crushed to accomplish a short melting time.

REGENERATIVE COOLING

Some chemicals require cooling so that impurities can be solidified and filtered off, for example, stearin from cod liver oil and cottonseed oil. Regenerative cooling can be used very effectively in this type of process. After filtering the cooled liquid can be used to cool the warm, unfiltered product in the first section of a plate-type heat exchanger. The remainder of the cooling is by direct or indirect refrigeration in the second section of the heat exchanger. With such a method only about 20 percent as much refrigeration is required as with a system using refrigeration through the entire range. This method has been used extensively in the food industry, especially in milk pasteurizing plants, and has wide possibilities in the chemical industry.

REFRIGERATION COSTS

For the cooling range above 32 deg. F., water is widely used as the refrigerant because of its ease of handling, high specific heat, low viscosity and low cost. Economical water evaporators can be designed to dehumidify air, condense vapors, and cool jackets or other processes. An evaporator for a refrigerant, however, cannot be as efficient owing to the large volume of vapor to be handled and also because of the refrigerant cost. Single-stage vapor compression, two-stage centrifugals, absorption and steam-jet systems are all used for water cooling. The type chosen will depend upon the size of the plant, the utilities readily available and the space available.

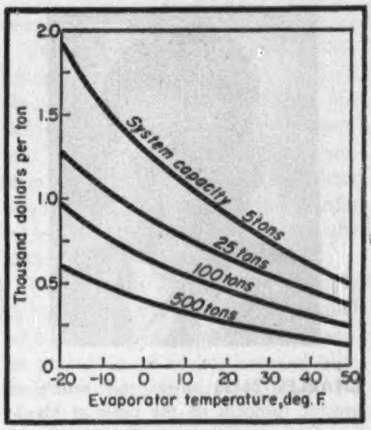


Fig. 11—AVERAGE COSTS of refrigeration plants for various evaporator temperatures. (Equipment only, installed.)

If the power for the drive is purchased, a motor-driven unit usually ends up lowest in first cost. If power is manufactured, steam-driven units become practical in the larger sizes. When waste heat or waste steam is available, absorption is practical.

From 32 deg. F. down to 0 deg. F. single-stage, multi-stage centrifugal, and absorption system are all used. These same systems are used, along with compound vapor compression, down to around -30 deg. F. At this point the single-stage vapor compression system can no longer be economically justified. Absorption plants have been used down to -50 deg. F. evaporator temperature.

For the temperature range from -30 down to -80 deg. F. multi-stage systems with reciprocating, rotary and centrifugal compressors are used. The tonnage of the plant sets the type of compressor used. From -80 down to -125 deg. F. the multi-stage and cascade systems compete. Below -125 deg. F. cascade systems may prove more economical from the first-cost standpoint, with possibly a slight disadvantage in operating cost from -125 down to -140 deg. F.

Although refrigeration costs will vary greatly depending upon the various items previously mentioned, an average value of dollars per ton for various size plants for evaporator temperature of -20 deg. F to $+50$ deg. F. is given in Fig. 11.

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Mr. Bliss's outside interests center around politics and government. In his home town of Ardsley, N. Y., he is a member of the board of trustees, the village's elected governing body. He has also served on the village planning board.

His work with Foster Wheeler involves extensive travel, which has included jobs in Europe and South America.

Tubular Process Furnaces

For direct heating or vaporization of process fluids by combustion of fuels, tubular furnaces fill the bill.

Except for the uses of electrical energy and byproduct heat of reaction, practically all process heating originates with the combustion of fuels. Liberation of the heat of combustion and absorption of that heat for useful purposes generally take place within a suitable enclosure, or furnace.

In many applications of combustion, the fuel is burned in direct contact with the material being heated. Examples are blast furnaces, glass furnaces and direct-fired kilns. In most combustion operations, however, the heat is transferred from the flame or the gaseous products of combustion through a wall of some suitable material, usually a steel or alloy steel tube.

The most common use of the latter type of furnace is, of course, the conventional boiler or steam generator. Design and operation of boiler plants is customarily outside the province of the chemical engineer, however, even though the availability of steam in adequate amounts and at the right pressures and temperatures is basic to the operation of many chemical processes.

Another type of furnace which will be excluded from this discussion is the fuel-fired batch still or kettle. In most process industries this type of equipment is being replaced by tubular furnaces, by electric heating, or by the use of heat-transfer media.

USES OF TUBULAR FURNACES

This article is concerned primarily with tubular fuel-fired process furnaces. Application of these furnaces to process work usually occurs where the required temperatures are above those normally available with steam, say, 450 deg. F. Some of these applications are:

1. Heating or vaporization of process fluids in petroleum and chemical plants, such as crude-oil heaters and fractionation tower reboilers.
2. Heating or vaporization of heat-transfer media, such as Dowtherm, petroleum oils and inorganic salts.
3. Supplying the endothermic heat of reaction for chemical processes which occur in the furnace tubes, such as thermal cracking of naphtha and steam reforming of methane.

Where chemical reactions occur within the tubes consideration must be given to the heating curve of the furnace. This curve is generally a graphical relationship between the temperature of the fluid and the distance traveled by the fluid from its entrance into the furnace.

THERMAL EFFICIENCY

Tubular furnaces can be designed for thermal efficiencies as high as 80 percent by providing sufficient surface in the convection section for exchange of heat contained in the flue gases against the incoming process fluid. Generally, a 300-deg. F. approach (exit flue gas temperature minus inlet process fluid temperature) is considered a good rule-of-thumb figure for economical operation.

Application of this rule may result in the discharge of flue gases which are still hot enough to permit additional recovery of heat. Where the savings in fuel warrant the additional investment, there are two choices of how to recover more heat—preheating of combustion air or generation of steam. Equipment for these duties can be designed either as additions to or integral with the furnace.

Air heaters enjoy an advantage over steam generators in that an actual reduction in the amount of fuel consumed is realized. Waste-heat steam generators, on the other hand, can generally be installed at a lower investment, providing a proper supply of condensate is available nearby.

The ultimate practical limitation on thermal efficiency is determined by the dewpoint of the combustion gases; below this temperature corrosion of tubes and other metal surfaces is severe, particularly when the combustion gases have a high sulfur oxide content.

NATURAL CIRCULATION

Tubular furnaces can be classified with respect to the method by which the fluid is circulated through the tubes—either natural convection or forced convection.

In the natural-circulation type of furnace, involving the partial or complete vaporization of a liquid, no charge pump is required. Flow through the tubes in the furnace is established by the head of a column of liquid in a colder part of the furnace working against a column of equal height of a lower-density mixture of liquid and vapor at a hotter point (the furnace tubes).

Natural-circulation furnaces in process heating are widely used for the generation of Dowtherm vapor. Such equipment, similar to steam-generation equipment, is shown in Fig. 1. The downcomer tubes are insulated against heat transfer to prevent vaporization of the liquid in these tubes. Thus circulation of the liquid Dowtherm is established from the upper to the lower drum, and thence as a liquid-vapor mixture from the lower to the upper drum through the heated furnace tubes.

FORCED CIRCULATION

A forced-circulation furnace consists of a number of metal tubes, special fittings to connect the tubes in the desired fluid-flow pattern, a refractory-lined structure, and burners to liberate heat within the enclosure. The entire assembly is designed to perform the expected function at minimum cost consistent with good operability and control and easy maintenance.

Fig. 2 illustrates a tubular heater of the type where the tubes are oriented vertically. Each tube extends the full height of the furnace, serving in both the radiant and convection sections. The radiant section of the tube receives heat primarily by radiation from the burner flames and by reradiation from the refractory lining. Because of the movement of the furnace gases within the enclosure a small proportion of the heat transfer will occur by convection.

The convection section of the tube receives its heat primarily by convection heat transfer, since in this region the combustion gases have been accelerated in velocity by reduction in the gas-flow area. A proportion of the heat transfer occurs by radiation, primarily from the carbon dioxide and water vapor in the combustion gases which surround the tubes. The furnace is operated under a slight negative pressure, which is established by the stack mounted on top of the structure. The burners are located in the floor and are fired vertically upward, using either a liquid petroleum fraction or a gas fuel.

Fig. 4 illustrates a design in which the tubes are oriented horizontally. Here the tubes are located in two distinct sections—the radiant section is designed for primary heat transfer by radiation from the burner flames, while the convection section is designed for primary heat transfer by convective means.

In order to increase the over-all thermal efficiency, a tubular air heater can optionally be located above the convection section. The air heater extracts heat from the combustion gases discharged to the atmosphere and transfers it to the combustion air for return to the furnace.

The furnace is operated under a slight negative pressure established by an induced draft fan, which discharges combustion gas from the air heater into the stack, and a forced draft fan, which discharges cold combustion air to the air heater. Ductwork from the air heater distributes the heated combustion air to the burners.

Fig. 3 represents an up-draft type of arrangement much the same as the design of Fig. 2 in that it contains a radiant section below the convection section, both designs having a stack above the structure. It differs from Fig. 2 in that the tubes are horizontally arranged.

UNIFORMITY OF HEAT-TRANSFER RATE

The rate of heat transfer to the tubes as related to the rate of heat liberated in the furnace is only one factor in furnace design. It is important to know also the degree of uniformity in the rate with which heat transfer to the tubes occurs in order to be able to establish economically attractive designs.

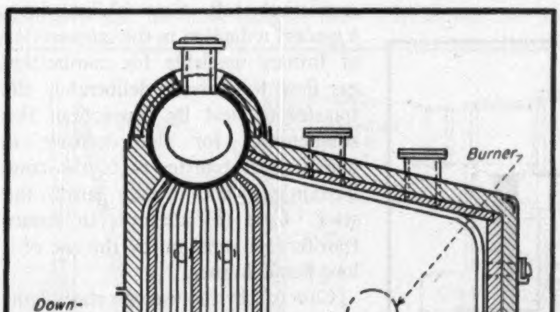
Therefore, it is not sufficient only to know that the furnace is designed for a certain average rate of heat transfer per sq. ft. of circumferential tube area, but these factors must also be considered:

1. How the rate of heat transfer to each tube in the furnace varies from the average rate.

2. For a given tube of the furnace, how the rate from point to point along the tube length varies from the average.

3. The variation of heat-transfer rate around the circumference of each tube.

The equipment designer can exercise wide control over the variation of radiant heat-transfer rate from tube to tube or from point to point along a tube, but he is quite limited in his control of the variation of actual heat-transfer rate when measured around the circumference of a tube. This control lies in his selection of tube spacing and/or his selection of whether tubes are to be fired on either one or both sides.



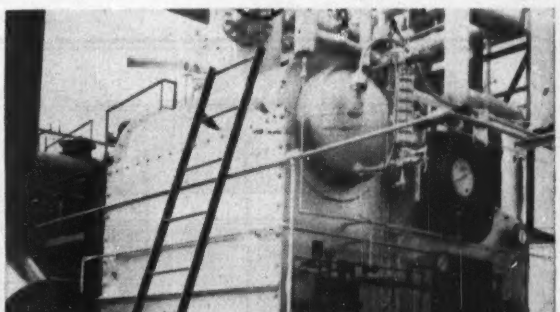


Fig. 1—NATURAL-CIRCULATION furnaces are widely used for generation of Dowtherm vapor.

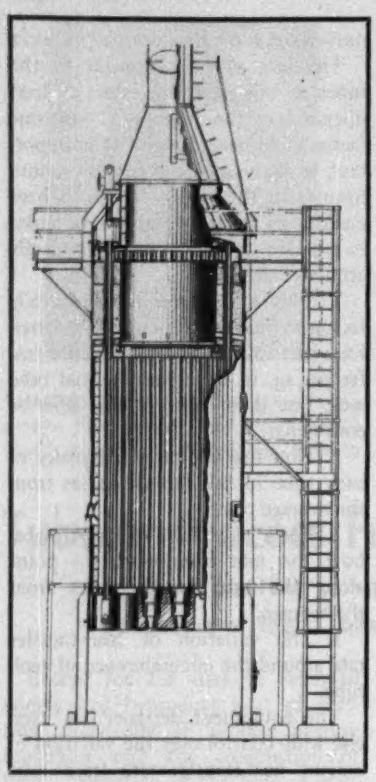


Fig. 2—VERTICAL tubular furnace.

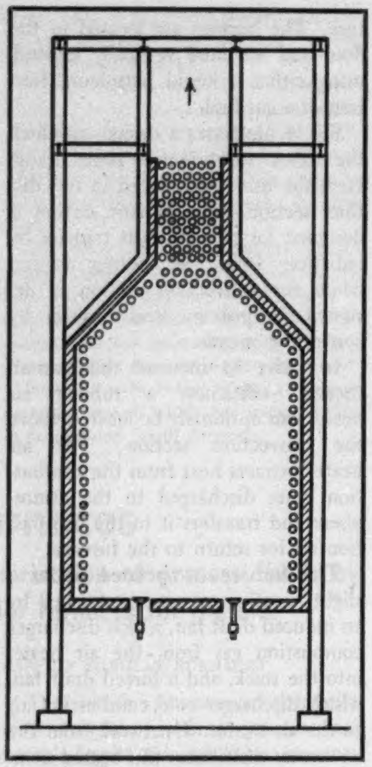


Fig. 3—HORIZONTAL tubular furnace.

However, greater tube spacings and dual firing each tend to increase the cost of the equipment. Such alternatives may not be justified, particularly when poor uniformity in transfer rates is expected from tube to tube, or longitudinally for a given tube.

EFFECT OF TUBE LENGTH

The control which the designer can exercise on the variation of heat-transfer rates longitudinally along a given tube is illustrated in Figs. 5 to 7. The curves showing transfer-rate variation along the length of a furnace tube include both radiation and convection. In any practical design—

1. Combustion gases must be removed from the furnace at some localized region, with an accompanying increase in velocity of the gases adjacent to portions of the tubes, which in such regions increases the convected heat to these portions.

2. Temperature of the furnace gases throughout the furnace is not necessarily uniform.

3. Reradiation from bare refractory walls varies both with the geometry of the furnace enclosure and with the location of the tube in a given geometric enclosure.

The rate of heat transfer to the tubes in a practical furnace will be the sum of these factors, and the variations of actual heat-transfer rate from average values shown in Figs. 5 to 7 are the result of radiant and convection mechanisms of heat transfer in the furnace expressed by these factors. It is assumed that firing conditions in the furnace are such that no actual flame impingement occurs on the tubes. It should be emphasized that the curves represent qualitative relationships only.

Fig. 5 represents variations in a vertical-tube heater with a relatively low furnace height where for Case (a) the burners are of the long-flame type and for Case (b) the burners are of the short-flame type.

Fig. 6 represents the variation in a vertical-tube heater where the furnace is relatively tall. Case (a) introduces a gradual reduction in the cross-section of furnace available for combustion gas flow to increase deliberately the transfer of heat by convection; this compensates for the decrease in radiant heat transfer as to the combustion gases cool in their path to the stack. Case (b) attempts to reduce transfer-rate variation by the use of a long-flame burner.

Case (c), by the use of a short-flame burner, makes no attempt whatever at uniformity.

Case (d) is an idealized condition—difficult to obtain—where small burners fire transversely to the longitudinal axis of the tubes, with the combustion gases removed from the furnace with a minimum convection heat-transfer effect.

Fig. 7 represents the variation in heat-transfer rate for a horizontal-tube furnace. Case (a) applies to double-

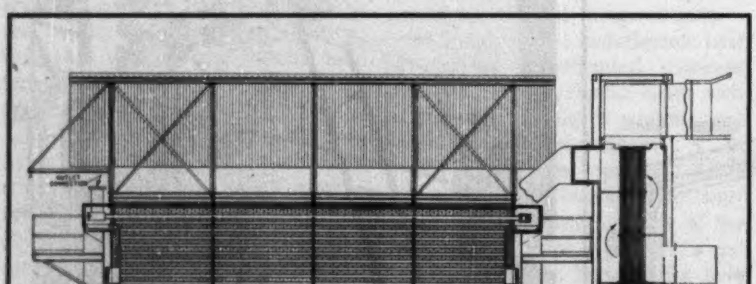


Fig. 4—HORIZONTAL furnace with two distinct sections and an air preheater.

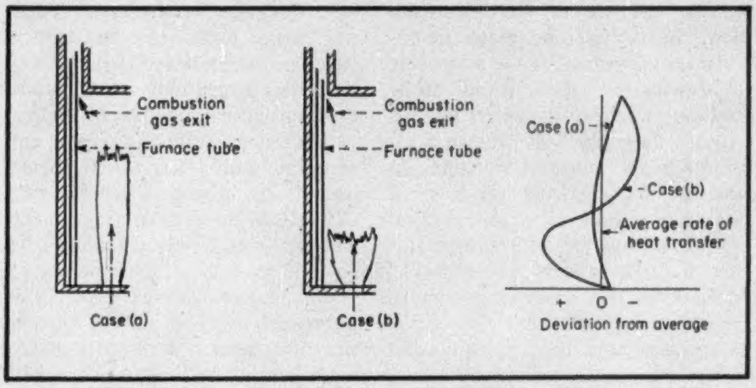


Fig. 5—LONGITUDINAL variations in transfer rate in short vertical furnace.

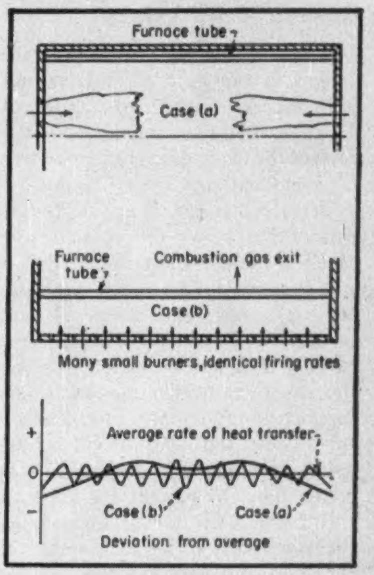


Fig. 7 — LONGITUDINAL variations in heat-transfer rate in a furnace with horizontal tubes.

end firing with burners having sufficiently long flames for the tube length considered. Case (b), which is identical with Case (d) of Fig. 6, is a widely used arrangement for horizontal-tube heaters.

EFFECT OF TUBE LOCATION

The foregoing concerns variations in heat-transfer rates circumferentially and longitudinally, always selecting one tube of a bank.

There is a further consideration of transfer-rate variation which involves the average rate of heat transfer as it changes from tube to tube. If a furnace contains a number of parallel flow-streams, each stream consisting of an equal number of tubes, and the change in the average heat-transfer rate from tube to tube is identical for each flow-stream, then such a variation, if kept relatively small, is unimportant, and the fluid temperature at the outlet end of each stream will be the same.

However, if such is not the case, identical outlet temperatures will not be obtained for each stream. This may or may not be important, depending on the function performed by the heater in the plant. In some cases, adjustment of flow rate of the charge fluid will produce identical outlet temperatures.

Where chemical reaction occurs within the tubes, it may be necessary to design for a predetermined variation of heat-transfer rate from tube to tube in a flow-stream; in such cases it may be justifiable to install some positive means of obtaining such a variation. As an example, bridge-walls may be installed to divide a large furnace into smaller furnaces, each utilizing a portion of the tubes of the flow-stream and each operating under its own average rate of heat transfer.

Generally speaking, a furnace with circular cross-section and with vertical tubes adjacent to the wall fired upward shows better uniformity in average heat-transfer rate from flow-stream to flow-stream than is found in the case of most horizontal designs. This is due to the identical geometric exposure of each flow-stream to the source of radiation. The reverse is true when considering variation of heat transfer longitudinally along individual tubes in a furnace with vertically oriented tubes.

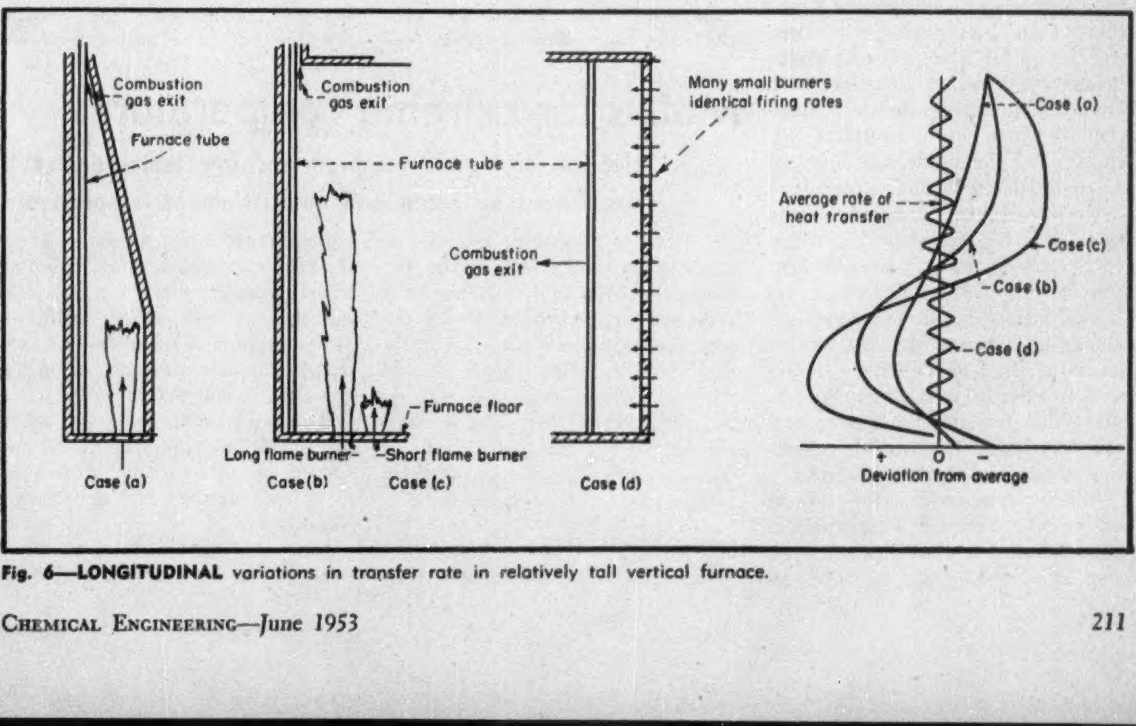


Fig. 6—LONGITUDINAL variations in transfer rate in relatively tall vertical furnace.

ECONOMIC CONSIDERATIONS

Having evaluated possible furnace designs in the light of these various technical factors, the final criterion of design is that the summation of the costs of the many different items entering into the design be a minimum.

Items which are chargeable to the cost of the heater proper are: The tubes; the return and terminal fittings which attach to the tubes; the insulated refractory walls, floor and roof, together with the hardware required to hold brick and insulation in place; the structural steel framework which supports the tubes, fittings and refractory walls; the alloy steel castings which are required in the case of horizontal tubes to support the tubes in the furnace; the fuel-burning equipment; concrete or brick chimneys, or the steel platework necessary for the stacks and connecting ductwork; and the materials for foundation work. The cost of erection and installation are functions of the type and character of the materials selected.

Associated with the fired tubular heater is the accessory equipment required for operation, such as instruments and control valves, safety controls, external piping for process and utility lines, and electric lighting.

Since in vertical furnaces each tube length serves both in radiant and convection service, the greatest advantage inherent in vertical tubes is the elimination of a considerable number of return fittings. On the other hand, vertical-tube designs for a given furnace duty will generally require longer tubes than horizontal-tube designs, and the cost of tubing per unit length increases with the total length of tube. However, the savings due to elimination of many return fittings is governing, and the result will represent an appreciable reduction in cost.

Horizontal tubes have an advantage over vertical tubes where the difference between the outlet and inlet temperatures of the fluid is relatively large, because the mean temperature difference between the combustion gases and the fluid in the convection section is less for vertical-tube designs. Additional heat-transfer surface will therefore be required in the convection section of such vertical heaters.

When specifications for tubular heater designs require throughputs so large that the maximum practical diameters of tubing are exceeded, requiring the use of multiple-stream flow, the vertical-tube heater of circular cross-section has the advantage of allowing the various streams to be arranged in the structure so that all streams have identical geometric exposure to the source of radiation. In the case of a horizontal-tube heater it is usually possible to obtain identical geometric exposure with two parallel streams; with four or more parallel streams, identity of exposure can be approached very closely.

However, the cost of equipment where more than four parallel flow-streams are used tends to increase because of the introduction of additional furnace wall area which may not be covered by heat-absorbing surface, and because of the increased cost of the special flow-pattern fittings.

The cost of intermediate tube supports is entirely eliminated in vertical-tube designs. Vertical-tube designs and some horizontal-tube arrangements permit locating the stack above the heater structure to save in foundations and in platework for breechings.

A criterion for the variation in cost of setting and structural steel framework is the percentage of the total wall area in the furnace which is covered by tubes. Vertical tubular heaters tend to show a higher percentage in this respect. External platform requirements will be reduced for vertical-tube heaters if comparisons are made between vertical and horizontal-tube designs on a minimum platform requirement.

Maintenance costs may affect the choice between vertical or horizontal furnaces. In general, costs are higher for vertical-tube designs because of the height of the maintenance platforms and method of tube replacement.

MORGAN M. HOOVER, author of this article, is associate editor of **Chemical Engineering.** With McGraw-Hill since 1949, his responsibilities have been largely associated with covering developments in materials of construction for chemical processing plants. He is responsible for the Corrosion Forum department of the magazine, as well as for the biennial reports on materials of construction. His editorial duties extend also into a variety of other subjects. Following graduation from Rensselaer Polytechnic Institute as a BS in chemical engineering, class of 1941, Mr. Hoover served as a production supervisor with the Du Pont company in plants making nylon, RDX high explosives, and plutonium; then, with American Cyanamid, as a production supervisor in a plant making titanium dioxide pigment. He is program chairman for next fall's management symposium sponsored by the New York Section, American Institute of Chemical Engineers.

Metals for Extreme Temperatures

Selection of metals for high and low temperatures is complicated by creep and embrittlement, respectively.

A trend to the use of extremes of temperatures and pressures in the chemical process industries has been underway for some time. Hence the need for metals and alloys to withstand such extremes. Some notable progress has been made in developing suitable materials, but there is much that should and undoubtedly will be done to better the present state of development of these materials.

HIGH TEMPERATURES

Examples of chemical processes requiring use of high-temperature alloys are catalytic cracking and reforming of petroleum fractions, thermal cracking of light hydrocarbons, synthesis gas preparation, Fischer-Tropsch synthesis, ammonia synthesis, oil hydrogenation, and methanol synthesis.

Reaction vessels, superheater tubes, regenerator grids, piping, valves, and turbine wheels are examples of equipment used in such high-temperature processing.

Creep—Metals used in high-temperature service are susceptible to

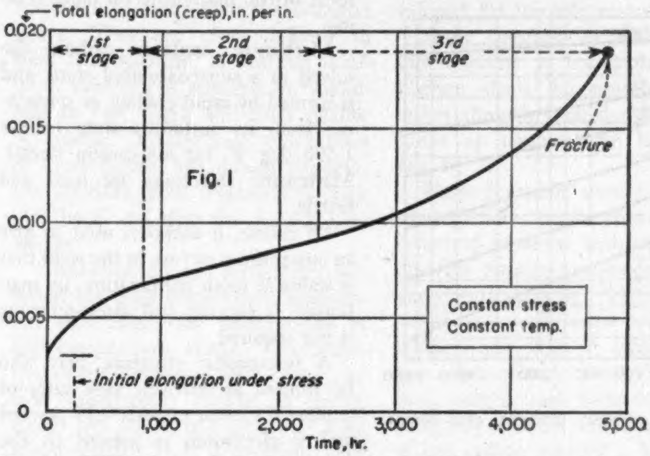


Fig. 1—**CREEP** limits usefulness of metals at high temperatures.

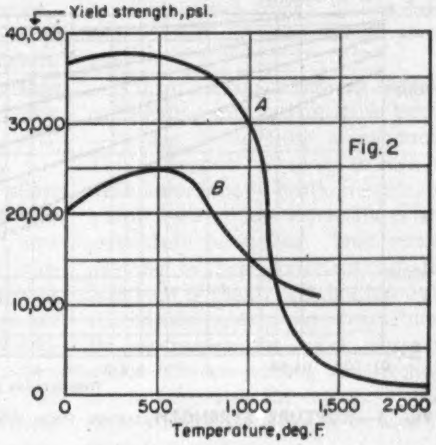


Fig. 2—**YIELD STRENGTH** falls off.

creep. That is, they tend to deform continuously and plastically under stresses below the short-time proportional or elastic limit. With carbon steels, creep enters the picture above 650 deg. F. approximately.

At room temperature, most high-melting metals return to their original shape provided they are not stressed beyond their elastic limit—regardless of the time under stress.

At higher temperatures where a metal is subject to creep, the elastic limit indicates the short-time behavior of the material only. The time factor enters the picture to complicate the selection of materials for high-temperature service.

A typical deformation-time plot for a metal undergoing creep at a stress below the short-time elastic limit is shown in Fig. 1. Note the three stages of deformation, each defined by a different rate of deformation with time. Amount of creep and the shape of the creep-time curve vary from metal to metal.

Allowable creep rates (such as 1 percent elongation in 10,000 hr.) are always based on the second stage of deformation (the straight section of the plot in Fig. 1).

The allowable creep rate for a given application may or may not be covered by code requirements. If not, the designer has considerable latitude in the selection of allowable stress that he may decide upon.

Creep tests of less than 500 hours do not mean much since this is the settling down period. Even the 500-hr. tests are not consistent enough for design purposes.

Yield Strength—The short-time yield strength of a metal is usually much lower at high temperatures than at low temperatures. Thus a limiting factor is imposed even before usefulness of the metal is further reduced by creep.

Plotted in Fig. 2 are the yield strengths of two metals vs. temperature. Note in this particular case the weaker metal at room temperature is the stronger one at high temperatures.

Rupture Strength—A metal with a high rate of creep may be chosen over one with a low rate of creep. This would probably be the case if rupture strength curves (Fig. 3) indicated that the material with the high creep rate had a longer life until failure at the proposed operating conditions—provided the allowable deformation due to creep was not exceeded.

Thermal Expansion—Where expansion due to heat is restricted, stresses will build up in a manner similar to compressive forces in action at room temperature. Similarly, if contraction due to removal of heat is restricted, tensile stresses will be set up in the material.

As creep occurs, thermal stresses below the elastic limit are relieved. A longitudinal round bar held between two immovable blocks, for example, would expand radially under plastic flow to make up the same volume it would have occupied were it free to expand in all directions. The time for stress relief due to creep depends on the temperature and the creep characteristics of the material.

Where two different metals are continuously welded together, as in a pressure vessel having an alloy steel liner and a carbon steel shell, differential expansion with heat may cause cracking to occur especially if there is a high frequency of thermal cycles.

Design—Considerations in high-temperature design vary in importance from application to application. The following* bears this out:

"In a superheater tube, expansion and elongation due to creep can be allowed for with no great trouble, but loss of strength, as reflected in need for thicker tube walls, must receive consideration, as must oxidation and corrosion. In a turbine wheel, on the other hand, close clearances put a strict limit on creep, and fatigue is important. Because stresses result largely from centrifugal force, heavier construction does not prove a satisfactory answer.

"In high-pressure piping, wall thickness can be increased within reasonable limits, but expansion presents a definite problem and any metal used needs to be adaptable to welding under field conditions. In high-temperature valves, differential expansion may work against tight seating."

High-Temperature Atmospheres—Mechanical and physical properties alone cannot determine the selection of the best metal for high-temperature service. The load-carrying ability of the metal may be quickly lost due to inadequate resistance to corrosion, which is greatly accelerated at high temperatures.

The type of corrosion-product film determines to a large extent the corrosion resistance of a metal or alloy. The

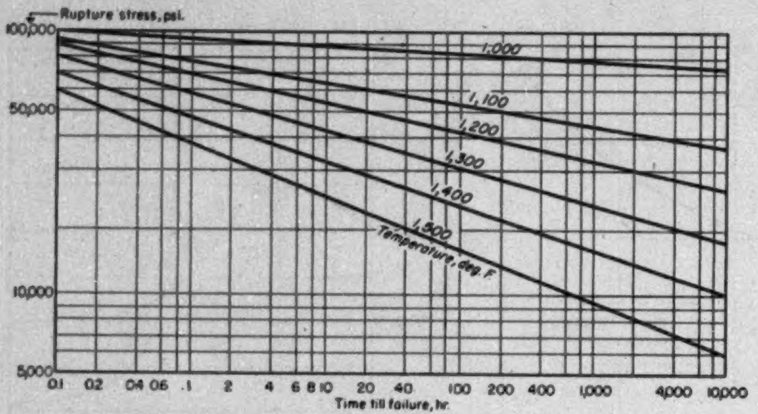


Fig. 3—RUPTURE STRENGTH curves show life at various loadings and temps.

ideal film is one which is dense and adherent—protecting the base metal from further attack. It is also a film that does not flake off due to stresses set up in alternate heating and cooling. Porous films offer little or no resistance to progressive attack.

Use of unalloyed steel is limited to temperatures of about 1,000 deg. F. because of oxidation. To get a dense, adherent protective oxide film above this temperature, a minimum of about 12 percent chromium is necessary. Since fuel is ordinarily burned with an excess of oxygen, materials in contact with flue gas in a combustion chamber such as tubes and tube supports are under high-temperature oxidizing conditions.

Steam is an oxidizing agent and at high temperatures may have a greater or lesser effect than air depending upon the alloy.

Alloying ingredients necessary to resist oxidation under various high temperature conditions are known from extensive experience. With other corrosive atmospheres such as H_2S, a background of experience is being built up so that proper alloying ingredients can be selected with some degree of assurance.

At temperatures above 1,300 deg. F., carbon containing gases and vapors may produce carburization of the alloy. Carbon is absorbed by the metal precipitating carbides. Result is loss of ductility. Tendency to carburize and the adverse effects of carburizing can be lessened by proper alloying.

In applications involving hydrogen at high temperatures and pressures, low alloy steel is susceptible to loss of ductility or to blistering due to absorption of hydrogen. Experience has shown that austenitic alloys resist hydrogen attack at high temperatures and pressures.

Under some extreme conditions, steels at high temperatures and pressures will absorb nitrogen to form a hard brittle nitride case that tends to crack. The presence of nickel minimizes nitriding.

Metallurgical — Metallographic structures of steels are important in that physical properties vary depending upon the structure. The heat treatment given may determine the crystal structure assumed.

Both (1) ferrite with iron carbide, and (2) austenite are important structures of steel for high temperature applications.

With austenite the carbon is in solid solution with the iron (or may be present as chromium carbide). The ferritic structure is composed of crystals of ferrite (practically pure iron) intermixed with crystals of iron carbide (cementite).

An austenitic structure is more resistant to creep than a ferritic structure.

The austenitic state in carbon steels is stable only above 1,500-1,600 deg. F., and reverts to ferrite on cooling slowly below 1,300 deg. F. A minimum of 8 percent nickel in high chromium alloys will preserve the austenitic structure down to room temperature. A minimum of 18 percent chromium is added to austenitic steels to insure that there will be adequate corrosion resistance.

A third structure, martensite, is important in connection with fabrication. Structures welded in the field have to be stress-relieved by special heat treatments if the weld areas tend to form brittle martensite on rapid cooling.

Martensite contains carbon dissolved in a super-saturated state, and is formed by rapid cooling or quenching from its austenitic state (above 1,600 deg. F. for low-carbon steels). Martensitic structures are hard and brittle.

Of course, if nickel is used to give an austenitic structure to the weld that is stable at room temperature, no martensite is formed and stress-relieving is not required.

A martensitic structure, may also be formed at relatively slow rates of cooling if carbon exceeds 0.35 percent and if chromium is present in the alloy. Molybdenum has the same effect, only to a lesser degree than chromium.

With over 16 percent chromium in the alloy, the structure tends to be ferritic rather than martensitic, and the steel is not hardenable on cooling from an elevated temperature.

Austenitic alloys cannot be hardened by heat treatment as can ordinary carbon steels, since they do not undergo a change in structure upon heating and cooling.

All austenitic steels have the ability to work harden. Operations such as forging, rolling, and drawing deform the crystal structure, resulting in increased hardness and strength. Operating temperatures must not exceed the temperature at which the metal will recrystallize back to the original, or annealed, condition. Elements such as molybdenum and tungsten may be added to increase the temperature at which this recrystallization will occur.

Austenitic alloys may be made precipitation hardenable by appropriate alloying additions. Precipitation hardening reaches internal areas not hardenable by working. Necessity of machining to final dimensions, usually required after work-hardening, is avoided by the precipitation hardening technique.

The precipitation hardening technique does not distort the shape of the piece being hardened. Hardening by heat treatment followed by quenching (as is possible with ferritic structures), does not distort the shape either, but this technique is applicable only to ferritic alloys.

Cast alloys used for high temperature service have in general greater

resistance to creep than the wrought alloys. They are often difficult to weld and machine. A limiting minimum thickness is required for soundness in cast alloys, and their quality is variable. Castings have, to a greater or lesser degree, low impact strength, low ductility, poor resistance to thermal shock, and often they have greater weight.

Graphitization and carbide precipitation are high temperature phenomena that affect the performance of high-temperature alloys. Graphitization is the decomposition of iron carbide (cementite) present in ferritic steels into ferrite and carbon at high temperatures. It is a problem with carbon and carbon-moly steels between 825 and 1,300 deg. F.

Graphitization may or may not be deleterious. If the graphite formed is uniformly distributed the room temperature strength is reduced and the creep resistance is lowered.

When the graphite forms in highly concentrated individual areas, as around a welded joint at the low temperature edge of the heat-affected zone, failure is likely due to loss of ductility.

Chromium restricts graphitization and a steel with 1 percent chromium will be practically immune to it.

Carbide precipitation occurs in austenitic chromium-nickel steels between 800 to 1,550 deg. F. The carbon present in solution combines with the chromium and precipitates out at the grain boundaries. This depletes the chromium content and hence makes the alloy more susceptible to corrosion.

Severe carbide precipitation leads to brittleness under some corrosive conditions. In many cases, however, it can be tolerated where corrosion is not a factor. Addition of titanium, columbium, or tantalum will inhibit carbide precipitation.

LOW TEMPERATURES

As the usefulness of metals at high temperatures is limited by creep, so is the usefulness of many metals limited at low temperatures because of embrittlement. Storage and transportation equipment for liquefied gases, refrigeration equipment, tonnage oxygen plants, propane and sulfur dioxide installations for dewaxing of petroleum stocks, and butyl rubber plants are users of alloys specially developed for low-temperature service.

Many common metals and alloys lose ductility as temperature lowers. Carbon steels, for example, change rather abruptly from ductile to brittle forms at temperatures below −20 deg. F.

There are some metals and alloys whose yield strengths are considerably improved at lower temperatures, and ductility remains unchanged or is reduced only slightly. These materials are often actually more useful at low temperatures than at room temperature. Examples are aluminum, copper, lead, nickel (and their alloys), and austenitic stainless steels (at least those of low carbon content). These materials remain effectively formable at the lowest attainable temperatures.[3]

Fine grain size, suitable crystalline structure, complete deoxidation (as with "killed" steels), and addition of certain alloying elements are listed as factors necessary for carbon steels suitable for low-temperature service.[4] A tempered martensitic structure of desired hardness level is preferable to a pearlitic structure of the same hardness level. Choice and amount of the beneficial alloying elements depend upon precise service conditions and economic factors such as availability and cost.

As regards carbon, resistance to embrittlement of carbon steels at low temperatures depends more on the degree of dispersion than the quantity present. A fine spheroidal dispersion of iron carbide is least detrimental to low-temperature properties[4] of carbon steels.

The designer of equipment for low-temperature service uses high-strength thin sections where possible in preference to lower-strength heavy sections. He uses the well-known principle that is applied to pressure vessel design, namely that heavy-walled pressure vessels tend to fail by brittle fracture, while those made up of layers give way in ductile fashion.

Conventional test for brittleness used by designers of low-temperature equipment is the notched-bar impact test (Charpy test). This test is good as a quantitative guide to the usefulness of different materials.

With plain carbon steel, there is no problem above −20 deg. F. From −20 to −50 deg. F., carbon steel may be used providing it meets the notch impact test (killed steel is usually specified in this range). Below −50 deg. F., it is necessary to start alloying.

If there is a choice between riveting and welding with carbon steels below −20 deg. F., riveting is preferred. This is because locked-up stresses in welds contribute to brittle fracture, to which steels at low temperatures are particularly susceptible. True, stress-relieving by heat treatment will relieve most of the stresses, but it is considered safer to rivet certain structures for low-temperature service where a choice between welding and riveting exists. Of course, the expense of the stress-relieving operation is avoided if riveting is used.

Thanks go to Robert Merims and R. M. Braca of Foster-Wheeler Corp. for their help in the preparation of the high-temperature section of this article. Their article in the February 1953 issue of *Chemical Engineering*, "How to Select Materials and Design Equipment for High Temperatures," is especially valuable in that it brings in the economics of high-temperature alloy selection.

Thanks go also to E. N. Skinner and F. L. La Que of the International Nickel Co., and to metallurgists of the Electro Metallurgical Co., a division of Union Carbide & Carbon Corp., for reviewing the article and offering a number of valuable suggestions.

The article by Rowley and Skrotzki[2] is particularly worthwhile to those who may have become "rusty" about how materials behave under stress, and the fundamental metallurgical considerations.

For a discussion of how specific metals behave at subzero temperatures, the article by Petty[5] is recommended. See the article by Friend[6] for the application of high-nickel alloy (Inconel, the Hastelloys) to extreme high-temperature services, also for behavior of other metals and alloys at high and low temperatures.

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Jean Raeburn

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Refractories for Every Use

Temperature limits for refractories are moving upward but maximum output per unit of cost still rules choice.

Although the refractories industry is a comparatively small one, it is critical because nearly all other industries depend on it. Refractories *contain* our heating processes, and their characteristics to a large degree determine the types of heating operations we can perform satisfactorily and economically. Without proper refractories we would be without steel production, steam generation, glass manufacture, portland cement, many chemicals—to mention only a few.

There is no ideal refractory for all applications. Choice of the most economical one in any case depends on a number of factors. In some cases very expensive refractories costing several dollars per brick may give the lowest refractory cost per unit of output. At the other extreme, sometimes the lowest cost fireclay brick obtainable may be the most economical. Installed cost per unit of production over the life of the refractory is the proper criterion for choice in most cases, rather than f.o.b. price. However, the cost of shutdowns and unplanned outages must be considered as well.

Refractories need not only withstand their necessary operating temperature without melting or shrinking, but they must be satisfactory from several other standpoints. For example, consideration must be given to their compressive strength under heat, to their tendency to disintegrate in furnace atmospheres of CO or H_2, to their resistance to erosion from slags, corrosive vapors or mechanical abrasion, and to splitting or spalling owing to rapid heating and cooling cycles.

By far the greatest proportion of refractories is produced in the standard weight types formed as brick, as special shapes or as tile. In addition, the industry makes light-weight insulating refractories; refractory castables, which are refractory-base granules mixed with hydraulic cement; ramming mixtures for monolithic refractory linings; and special materials such as high-temperature ceramic coatings for metals, and the metal-ceramic combinations called cermets.

Refractories produced in the form of brick and tiles are summarized in Table I.

ALUMINA-SILICA REFRACTORIES

Fireclay Refractories—Fireclay refractories constitute the largest group of refractories produced. They are made largely from fireclays obtained from New Jersey, Kentucky, Pennsylvania, Ohio, and Missouri and are divided into four main groups, based partly on maximum service temperatures which they can withstand. These groupings are: (1) Low-duty fireclay brick; (2) intermediate fireclay brick; (3) high-duty fireclay brick; and (4) superduty fireclay brick.

Fireclay brick as a group are relatively cheap. They are used to some extent in almost every furnace structure built, where operating temperatures are within their temperature service range and where no special conditions of reducing furnace atmospheres or special problems are encountered. Their low cost makes them an economical material.

Alumina-Diaspore Fireclay Brick—These brick have a higher melting

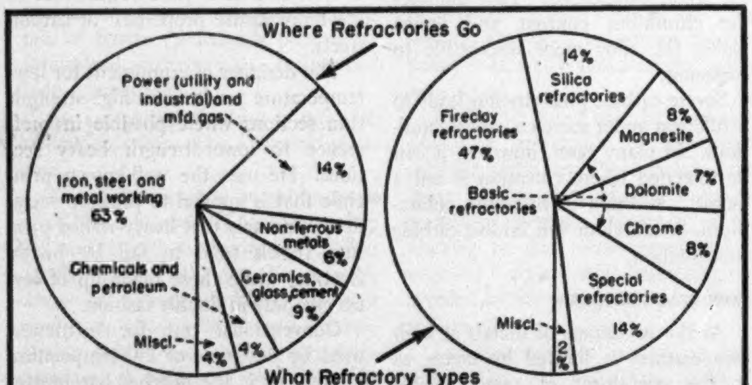


Fig. 1—REFRACTORIES by destination and types. The chart on the left shows how refractories use breaks down by industry groups. Chemical process industries include a part of the power group, a part of the non-ferrous metals group, the ceramic, chemical and petroleum groups. The chart on the right shows that fireclay refractories, including all clay brick as well as insulating refractories, mortars, plastics and castables, encompasses nearly half the total industry product. The special refractories include fused alumina, SiC, mullite, sillimanite, forsterite, zircon, carbon and other special refractories, and their non-brick forms.

Table I–Classification and Use Properties of Refractory Brick

Name	Composition, Percent	Melting Point, °F.	Normal Use Limit, °F.*	Approx. $/M, 9-in. Equiv.	True Specific Gravity	Bulk Density, Lb./Ft.³	Source
Alumina-Silica							
Fireclay base							
First quality	35–40 Al_2O_3 54–60 SiO_2	3,090–3,175	2,400–2,700	95	2.60–2.70	125–140	Fireclay
Semi-silica	70–80 SiO_2	2,940–3,060	2,400–2,700	100	2.40–2.45	125–140	Fireclay
Superduty	41–45 Al_2O_3 51–55 SiO_2	3,175–3,200	2,500–2,800	115	2.65–2.75	130–145	Flint fireclay
High burned superduty	41–45 Al_2O_3 51–55 SiO_2	3,175–3,200	2,500–2,800	155	2.65–2.75	130–145	Flint fireclay
50% alumina	50 Al_2O_3	3,200–3,245	2,500–2,800	160	2.75–2.85	130–145	Fireclay, diaspore, bauxite
60% alumina	60 Al_2O_3	3,245–3,310	2,700–2,900	200	2.90–3.05	130–145	Fireclay, diaspore, bauxite
70% alumina	70 Al_2O_3	3,290–3,335	2,700–2,900	235	3.15–3.25	135–150	Diaspore, bauxite
80% alumina	80 Al_2O_3	3,335–3,390	2,800–3,000	260	3.35–3.45	140–155	Diaspore, bauxite
90% alumina	90 Al_2O_3	3,390–3,425	2,800–3,200	1,175	3.55–3.65	172	Calcined alumina
Kyanite base	$Al_2O_3 \cdot SiO_2$ 58–68 Al_2O_3	3,250–3,300	2,800–3,000	500–680	3.00–3.06	140–150	Kyanite
Kaolin base (High-fired)	$Al_2O_3 \cdot 2SiO_2$ 44–45 Al_2O_3	3,190	2,800–2,900	170–335	2.65–2.75	135–145	Kaolin
Fused mullite base	$3Al_2O_3 \cdot 2SiO_2$ 72–75 Al_2O_3	3,325–3,350	2,900–3,200	685–1,370	3.08–3.25	150–160	Bauxite and synthetic
Silica							
Standard	SiO_2	3,142 (pure)	3,000	95–100	2.30–2.38	100–105	Quartz sand, ganister
Superduty	SiO_2	3,142 (pure)	3,000 plus	110	2.30–2.38	100–105	Quartz sand, ganister
Magnesite							
Burned	MgO plus SiO_2, Fe_2O_3, Cr_2O_3	5,070 (pure)	3,000–4,000	520	3.40–3.60	160–165	Magnesite, sea water, brines, brucite
Chemically bonded	MgO plus FeO, Cr_2O_3		2,900–3,100	465	3.60–3.80	170–175	Magnesite, sea water, brines, brucite
Chrome							
Burned	$FeO \cdot Cr_2O_3$ pure; plus some Al_2O_3, MgO, Fe_2O_3, SiO_2	3,540–3,990	2,800–3,200	430	3.60–4.10	185–190	Chromite ores
Chemically bonded	$FeO \cdot Cr_2O_3$ plus MgO	3,540–3,990	2,900–3,100	450–485	3.90–4.10	170–190	Chromite ores
Forsterite	$2MgO \cdot SiO_2$	3,461 (pure)	3,000	530	3.30–3.40	150–155	Olivine or synthetics
Silicon carbide	SiC	Dissociates at 4,082	2,800–3,200	1,520	3.19	155	Synthetic
Fused alumina	Al_2O_3	3,722 (pure)	3,400	2,000	3.70–3.90	175–195	Bauxite
Zircon	$ZrO \cdot SiO_2$	4,532 (pure)	3,400	1,210	4.70	205	Zircon sands
Zirconia (Stabilized)	ZrO_2	4,870 (pure)	4,300	9,430	5.75	275	Zircon sands
Carbon (Graphite)	C	6,330	4,000 (reduc. atm.)	1,600	2.25	137	Carbon

* **Note:** "Normal-use-limit" temperatures are approximate only because service conditions sometimes will change allowable temperatures by several hundred degrees. Such conditions may include heavily reducing atmospheres and unusual loading.

point and an alumina content which varies from 50 to 70 percent. As a class, they are used much less than the ordinary fireclay brick because of their higher price. They are used only where their higher use limit and melting point, and in some cases resistance to slag, make them a more economical selection. One important use of the 70 percent alumina type is in the linings of rotary cement kilns.

Special Alumina-Silica Refractories—In this classification we have the sillimanite and mullite types usually made from kyanite with an over-all alumina percentage between 58 and 65 percent. These bricks are considerably more expensive than the alumina-diaspore class and are used where the service temperature of this latter group is exceeded.

In this classification are also the kaolin base refractories which are made from relatively pure china clay which has been heated to very high temperatures to render it volume stable at high application temperatures.

Also in this group are mullite refractories which have a true mullite composition with an alumina content of approximately 75 percent. These brick are usually made from electrically fused mullite grain, with a bond which also develops theoretical mullite compositions on firing. These brick have extremely good compressive strength under load at high temperatures. They resist rapid heating and cooling cycles, and are resistant to certain types of slag attack. They are volume stable at higher temperatures than the refractories previously listed.

SILICA REFRACTORIES

Silica refractories are the second largest group of refractories produced and large quantities of them are used by the steel and glass industries. They are made from crushed sandstone or quartzite, bonded with a small amount of lime water. Silica brick have the advantages of being relatively low priced and have good load bearing capacity at high temperatures close to their melting point. Because of their thermal expansion characteristics they have poor resistance to rapid heating and cooling and for that reason are used primarily in furnaces where the temperature is held constant for long periods of time.

Recently a new development in silica refractories has been made, known as the superduty silica brands. This superduty silica brick is one in which the total alumina content is lower than in the normal brands and as a result it has a somewhat higher use limit than the standard silica refractories.

MAGNESITE REFRACTORIES

Magnesite refractories are produced from calcined magnesite rock or from calcined magnesium carbonate recovered from sea water. In the heating process the CO_2 contained in the magnesium carbonate of the starting

material is driven off to form MgO. The MgO granules are then bonded, sometimes with the addition of chrome ore, to form bricks and shapes. Some of these are fired to high temperatures as in the case of other refractories and some are chemically bonded by a process which requires no firing. Magnesite brick are used mainly where they are in contact with basic slags. These brick are considerably more expensive than fireclay brick and for that reason are used where the cheaper fireclay brick will not give an economical life.

There is also a type of electrically fused MgO refractory produced from nearly pure magnesia which has a higher use limit than normal magnesite brick, suitable for use at very high temperatures.

CHROME REFRACTORIES

Chrome refractories are produced from natural chrome ore and, like magnesite, can be made either as fired or as chemically bonded brick. The chemically bonded structures always contain some MgO additions. Chrome brick is relatively neutral chemically and does not react at moderately high temperatures with silica, magnesite, or alumina refractories. For that reason it is often used as a separator in furnace constructions between two refractories which would react with each other if allowed to come into contact.

FORSTERITE REFRACTORIES

Forsterite refractories are usually made from olivine rock to which some MgO has been added to adjust the composition ratio to $2MgO \cdot SiO_2$. Forsterite refractories can also be made by synthetic mixtures of MgO and SiO_2. These refractories are made only as a fired refractory and are reported to be particularly good against the attack of alkali vapors at high temperatures.

SILICON CARBIDE REFRACTORIES

Silicon carbide is an electric furnace product used primarily as an abrasive and is known under trade names such as Carborundum and Crystolon. When this material is produced in refractory shapes it provides a very high rate of heat conduction, approximately 10 times that of fireclay brick. (See Fig. 2. Due to its hardness it is sometimes used where mechanical abrasion is severe and also where it is exposed to certain types of slag. Its property of high heat conduction, however, is probably its outstanding physical characteristic and for this reason it is used widely for muffles and various air-cooled furnace and recuperator constructions.

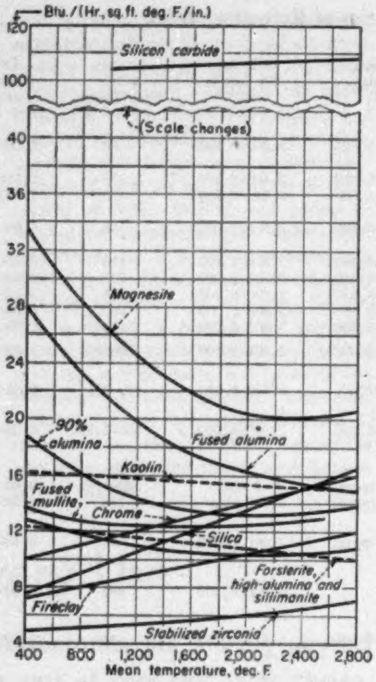


Fig. 2 — REFRACTORY BRICK show widely varying thermal conductivities. (Data from various sources; values vary considerably depending on test method.)

FUSED ALUMINA REFRACTORIES

Fused alumina is another electric furnace product whose primary use is in abrasives. When compounded into refractory shapes it also has a high heat conduction, but considerably lower than silicon carbide. Its heat flow is approximately 2.5 times that of ordinary fireclay brick. It is also used for muffles and air cooled sections and replaces silicon carbide where the latter is unsatisfactory for other reasons. It has a very high use limit in both oxidizing and reducing atmospheres and it is used where extreme temperature levels rule out other materials.

ZIRCON REFRACTORIES

Zircon refractories are made mainly from the natural mineral zircon which is often found concentrated in certain beach sands. It has a high melting point and use limit and is resistant to some types of siliceous slags.

ZIRCONIA REFRACTORIES

These refractories are made from purified zirconium oxide with small additions of lime, magnesia, or other ingredients to render it stable in volume. Pure unstabilized zirconium oxide inverts on cooling from the high temperature form to a low temperature form with a considerable volume change which is sufficient to cause cracking and disintegration. The stabilized structure retains the high temperature form on cooling without undergoing a change in volume. These refractories have a very high melting point and use limit and are employed where extreme temperatures are encountered. An interesting physical property is that even at extremely high temperatures the thermal conductivity is low so that the heat flow through a furnace section is relatively low. These refractories are relatively high priced and can be justified economically only for extreme use.

CARBON REFRACTORIES

Carbon (graphite) refractories are produced by heating a mixture of tar and coke. The refractories in brick or block form have been used in blast furnaces and in some other industries. They are limited to applications where the furnace operates reducing.

INSULATING FIREBRICK

Insulating firebrick are produced mainly from clays which are mixed with some type of combustible material such as sawdust. When fired, the combustible material burns out, leaving a highly porous refractory structure. These light-weight products can be used as the exposed lining in the furnace chamber in the same way as other refractories. They are made in several grades, the lowest grade being suitable for temperatures of 1,600 deg. F., and the highest temperature grade being satisfactory at 3,000 deg. F. The weight per brick ranges between 1.25 and 4 lb. as contrasted to 8 lb. for a standard firebrick.

It is the low weight of these refractories which makes them of importance. The time necessary to raise a cold furnace to operating temperature is proportional to the weight of the furnace lining, assuming equal fuel inputs to the structure. Likewise,

Table II—Classification of Insulating Firebrick

Type *	Composition, Percent	Normal Use Limit, °F.†	Approx. $/M, 9-in. Equiv.	Bulk Density, Lb./Ft.³
Group 16	15-37 Al_2O_3, 30-60 SiO_2 plus TiO_2, Fe_2O_3, Alk.	1,600	115	21-37
Group 20	26-38 Al_2O_3, 45-61 SiO_2 plus TiO_2, Fe_2O_3, Alk.	2,000	125	26-45
Group 23	25-42 Al_2O_3, 45-67 SiO_2 plus TiO_2, Fe_2O_3, Alk.	2,300	150	27-47
Group 26	40-46 Al_2O_3, 47-55 SiO_2 plus TiO_2, Fe_2O_3, Alk.	2,600	195	43-64
Group 28	45-53 Al_2O_3, 42-52 SiO_2 plus TiO_2, Fe_2O_3, Alk.	2,800	260	45-65
Others	45 Al_2O_3	2,900	285	52
	65 Al_2O_3	3,000	480	69
	90 Al_2O_3	3,250	750	81

* Group number is std. A.S.T.M. classification, indicating normal use limit (×100).
† See note under Table I.

Table III—Classification of Refractory Castables
(Refractory aggregates plus hydraulic cement)

Name, Standard Types	Composition	Normal Use Limit, °F.*	Approx. Cost, $/T., CL	Bulk Density, Installed & Fired, Lb./Ft.³
Alumina-Silica				
Fireclay type	Al_2O_3, SiO_2 plus CaO, Fe_2O_3, TiO_2, Alk.	2,400-2,700	60-75	100-140
Superduty type	Al_2O_3, SiO_2 plus CaO, Fe_2O_3, TiO_2, Alk.	2,700-3,000	100-170	100-140
Chrome	$FeO \cdot Cr_2O_3$ plus Al_2O_3, CaO, SiO_2	2,700-3,100	90-150	160-190
Insulating Types				
Expanded mica		1,600-1,800	....	40-50
Diatomaceous base	SiO_2 plus Al_2O_3, impurities	1,800-2,000	....	55-70
Bloated clay base	Al_2O_3, SiO_2 plus CaO, Fe_2O_3, TiO_2, Alk.	2,000	....	70-100
Porous refractory base	Al_2O_3, SiO_2 plus CaO, Fe_2O_3, TiO_2, Alk.	2,000-2,500	90-130	50-90

* See note under Table I.

Table IV—Classification of Refractory Plastics and Ramming Mixes

Name	Composition	Melting Point, °F.	Normal Use Limit, °F.*	Approx. Cost, $/T., CL	Bulk Density, Installed & Fired, Lb./Ft.³
Alumina-Silica					
Fireclay base	Al_2O_3, SiO_2, plus Fe_2O_3, TiO_2, Alk.	2,850-3,100	2,500-2,700	50-70	125-140
Superduty base	Al_2O_3, SiO_2, plus Fe_2O_3, TiO_2, Alk.	....	2,700-3,000	60-80	130-140
Kyanite base	$Al_2O_3 \cdot SiO_2$, plus Fe_2O_3, TiO_2, Alk.	....	3,000-3,100	150-175	140-150
Fused mullite base	$3Al_2O_3 \cdot 2SiO_2$ plus Fe_2O_3, TiO_2, Alk.	....	3,000-3,200	175	150-160
Silica	SiO_2	3,142 (pure)	2,800-3,000	......	100-105
Magnesite					
Grain	MgO	5,070 (pure)	2,900-3,100	70-100	150-160
Mixtures	....	....	....	......	145-165
Dolomite	$CaO \cdot MgO \cdot 2CO_2$	4,650-5,070 (pure)	2,900-3,100	......	....
Chrome	$FeO \cdot Cr_2O_3$ plus Al_2O_3, MgO	3,765 (pure)	2,900-3,100	95-110	180-200
Silicon carbide	SiC	Dissociates at 4,082	2,800-3,150	......	150-170
Fused alumina	Al_2O_3	3,722 (pure)	2,900-3,400	......	175-195
Zircon	$ZrO \cdot SiO_2$	4,532 (pure)	3,200	......	205
Zirconia (Stabilized)	ZrO	4,870 (pure)	3,800	......	275

* See note under Table I.

the time necessary to cool the furnace structure down is proportional to the weight. In actual practice it is not uncommon to effect fuel reductions of 30-65 percent in a cyclic heating process when insulating firebrick are substituted for standard refractories.

The high porosity of insulating firebrick also gives them a low heat flow, the thermal conductivity being roughly proportional to their weight as shown in Fig. 3. This means that for continuous heating operations, thin wall sections can be used having the same heat flow as more massive firebrick sections backed up by insulation.

Insulating firebrick have application limitations, however, and are confined to heating operations where there are conditions of clean heat, freedom from mechanical abrasion, and freedom from slag. It is largely because porous structures are unsatisfactory when subjected to slag that insulating firebrick are made from alumina-silica compositions, since the better slag resisting properties of magnesite, chrome or similar materials would have little advantage in a sponge-like texture.

REFRACTORY CASTABLES

Refractory castables are concretes, similar to structural concrete except that the sand and gravel of structural concrete is replaced by a carefully prepared and sized aggregate of crushed refractory material. The cement used is usually the same as in structural concrete, being portland or high-alumina cement. More recently, a more refractory cement composed of nearly pure lime and alumina in the

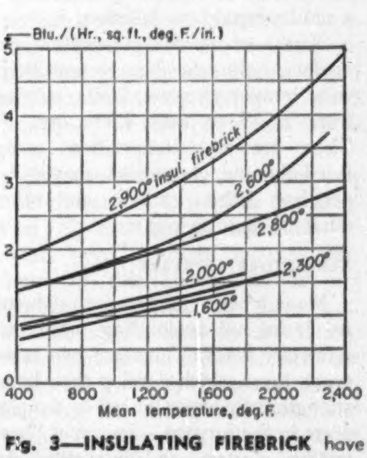


Fig. 3—INSULATING FIREBRICK have thermal conductivities much below most standard weight refractories. (Data on one maker's products.)

ratio of $3CaO \cdot 5Al_2O_3$ has been used. With alumina-silica base aggregates, castables are available for service temperatures from 2,400 deg. F. to temperatures somewhat above 3,000 deg. F. The alumina-silica base castables constitute the bulk of the market, although special castables are made with chrome, fused alumina and other bases.

Just as in the case of preformed refractories, there is a class of lightweight castables made by using a porous aggregate. The advantages of light weight in a castable are the same as in the case of insulating firebrick.

At the present time, the general use of castables is being extended considerably due to their low cost of installation. Refractory concrete is mixed and placed in a manner similar to structural concrete, and is a desirable material to use in areas where skilled brickmasons are hard to obtain. When the proper grade is selected for a given application, a castable will provide a volume stable monolithic lining in many instances giving equal or better service life than a lining of regular brickwork.

PLASTIC AND RAMMING REFRACTORIES

There is another group of refractory products known as plastic refractories or ramming mixes. These compositions are generally composed of clays or other binders mixed with crushed refractory aggregate and tempered with water to bring the mixture to proper working consistency. The plastic or ramming mix is installed by pounding or ramming into place, and for this reason the installation costs are usually somewhat higher than for a similar castable installation.

Plastic or ramming mixtures are made in alumina-silica compositions with temperature use limits ranging from 2,500 to over 3,000 deg. F. There are also compositions using fused alumina, chrome ore, magnesite, periclase, silicon carbide, and other refractory base aggregates.

REFRACTORY MORTARS

Many types of mortars are produced for laying up or jointing preformed refractory brick. There are two main types, those which develop their bond strength only when heated to temperature in the furnace— known as "heat setting" mortars—and those which develop a high bond on drying, called "air setting" mortars. Both types have their applications, and the best guide is to follow the recommendation of the manufacturer supplying the brick used with the mortar.

METAL-CERAMIC COMBINATIONS

Various combinations of ceramic materials have been used as coatings on metals, including parts for nuclear reactors and heat-resistant components for both jet-propulsion and reciprocating aircraft engines. These coatings can be used to impart chemical inertness at high and low temperatures to the metal, and have good thermal shock resistance and low porosity. Ceramic-coated low-alloy steels can replace the higher alloyed strategic materials. These coatings reduce oxidation and inter-granular corrosion of the base metal up to a temperature of 1,900 deg. F. Although the better coatings contain a considerable portion of strategic material in their composition, the thinness of the coating together with the substitution of lower alloy content steels represent a considerable over-all saving in strategic materials. The U. S. Bureau of Standards and several industrial concerns have done considerable work in developing this type of material. Many of these mixtures consist essentially of an enameling frit of alumina and silica with additions of metallic oxides such as chromium and cobalt.

Another approach to metal-ceramic combinations which has spurred considerable research in recent years is the class of cermets. This work has been prompted by the scarcity of high-temperature metals requiring strategic materials. Cermets are mechanical and chemical combinations of metals and ceramics whose properties in the combined state differ from those of either component. Ceramic materials themselves are limited by low tensile strength and thermal shock resistance, whereas metals have good tensile and shock-resistant properties, but lose rapidly with increase in temperature. Cermets attempt to blend the desirable properties of both, securing the advantages of improved thermal shock resistance, wear resistance and mechanical strength at elevated temperatures, compared with ceramics. Also they have a higher strength-to-weight ratio than ordinary refractories. They can be formed by methods similar to those used in powder metallurgy. Usually, the ceramic components are refractory oxides, carbides and nitrides, while such metal components as chromium, nickel, molybdenum and titanium are used. Hence such materials are costly, and many of the available types require strategic materials.

SPECIAL REFRACTORIES

The refractory products which have been described above constitute the bulk of refractories which are in commercial production and are readily available. In addition to these products, there are many other refractory materials which have been used only on limited or small-scale applications. To give a picture of the possibilities of these materials a list has been made in Table V of materials having melting points reported to be in excess of 4,000 deg. F. These might well be termed the refractories of the future, since if processes are carried out at higher and higher temperature levels, refractories for furnace constructions may be drawn from this list or from other untested materials of similar characteristics.

Table V—Refractory Compounds with Reported Melting Points Above 4,000 Deg. F.

Material	Formula	M.P., °F.
Oxides		
Beryllium oxide (Bromellite)	BeO	4,580
Calcium oxide (Lime)	CaO	4,660
Cerium oxide	CeO_2	4,710
Chromium oxide	Cr_2O_3	4,410
Hafnium oxide	HfO_2	5,090
Lanthium oxide	La_2O_3	4,208
Magnesium oxide (Periclase)	MgO	5,070
Strontium oxide	SrO	4,410
Thorium oxide	ThO_2	5,520
Yttrium oxide	Yt_2O_3	4,370
Zirconium oxide	ZrO_2	4,870
Silicates		
Zirconium silicate (Zircon)	$ZrO_2 \cdot SiO_2$	4,532
Nitrides		
Boron nitride	BN	5,432
Hafnium nitride	HfN	5,970
Scandium nitride	ScN	4,800
Tantalum nitride	TaN	6,080
Titanium nitride	TiN	5,250
Zirconium nitride	ZrN	5,340
Borides		
Hafnium boride	HfB	5,549
Tungsten boride	WB_4	5,288
Zirconium boride	ZrB_2	5,414
Carbides		
Boron carbide	B_4C	4,230
Calcium carbide	CaC_2	4,170
Columbium carbide	CbC	6,330
Hafnium carbide	HfC	7,530
Molybdenum carbide	Mo_2C	4,320
Silicon carbide	SiC	4,890
Tantalum carbide	TaC	7,020
Thorium carbide	ThC_2	5,020
Titanium carbide	TiC	5,670
Tungsten carbide	WC	5,036
Uranium carbide	UC	4,350
Vanadium carbide	VC	5,130
Zirconium carbide	ZrC	6,380
Zirconates		
Barium zirconate	$BaO \cdot ZrO_2$	4,748
Calcium zirconate	$CaO \cdot ZrO_2$	4,262
Strontium zirconate	$SrO \cdot ZrO_2$	>5,072
Thorium zirconate	$ThO_2 \cdot ZrO_2$	5,072

COMBUSTION

(Continued from p. 194)

Inasmuch as price and availability of fuels are subject to constant change, ability to shift from one fuel to another, or to burn them in combination, is sometimes highly desirable. Fig. 14 shows a multi-fuel burner suitable for pulverized coal, oil and gas.

JET BURNERS

Turbojets put unusually strong demands upon combustion systems, including (a) high heat release per unit volume, (b) complete combustion and (c) low final temperature. Space limitations dictate the first, turbine blade protection the last two requirements.

Space limitations also dictate the use of pressure-atomizing oil burners. In addition, high engine efficiency requires low pressure-drop across the burner.

The fuel is a distillate intermediate between kerosene and gasoline, supplied at pressures up to 1,000 psi. To gain wide turndown ratios (20:1) nozzles providing for controlled recirculation or two nozzles in one housing (duplex type) are used.

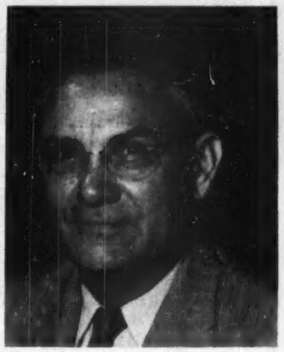
The so-called can-type jet burners have provision for eddy-type flame stabilization in gales of 50 to 100 fps. and perforated liners (flame baskets) for admission of secondary and cooling air. One type of burner, the straight-flow can, has a liner of gradually increasing diameter, followed by a converging section just upstream of the turbine. About a dozen cans are arranged around the engine shaft between the compressor and turbine. Another type, the annular burner, is continuous around the shaft, with equally spaced burner nozzles and a liner having a thin V-shaped cross-section in the plane of the engine axis.

Burner output is about 4 million Btu. per (hr.) (cu. ft.) and in some cases as high as 28 million, compared with 20,000 to 100,000 for boiler furnaces.

The principle of the pulse-jet, or V-1 guided missile, is being studied in Germany for use in industrial combustion processes. Initial application under test is for coal gasification (see *Chem. Eng.*, May 1953, p. 144), although fundamental experimental work has made use of gasoline as a fuel.

The combustor consists of a tube, open at one end and closed at the other by a one-way valve. A fuel-air mixture in the tube burns in pulsating combustion or in a sequence of explosions. After the first charge is ignited the combustion turns into an explosion with a sharp increase of pressure. This pressure closes the valve and forces the gases and air out of the opposite end of the tube. The inertia of the exhausting gases causes a pressure drop to a value below atmospheric pressure. Thus, the valves are opened again and more air as well as fuel is sucked in, forming another fresh charge.

In the meantime, the gas column develops a reverse motion, because of the low pressure in the tube, and builds up a new pressure wave by the inertia of the mass of air. The combined effect of pressure, temperature and free radicals remaining from the previous combustion gas results in a fresh ignition of the charge and the combustion cycle starts anew.



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He is past chairman of ASTM Committee C-16 on thermal insulation materials and last year received the ASTM Merit Award for work in this field.

The Thomas system of dimensional standards for thermal pipe insulation, used by most manufacturers, was originated and developed by our author.

Although lacking a college degree, Mr. Thomas has achieved through self-education the status of registered professional engineer and listing in "Who's Who in Engineering."

W. C. Turner, who collaborated in the preparation of this article, has been with Carbide 12 years.

Insulation for Heat and Cold

Materials and application methods must be hand-picked for the service requirements of the installation.

The primary function of an industrial thermal insulation is to resist the flow of heat. The thermal properties of a candidate material are, therefore, the first to be considered.

In many instances, however, the particular material used is chosen because of favorable mechanical properties rather than thermal properties. Each job where insulation is to be used has its own set of requirements. These requirements should be checked against the list of material chacteristics (*Table II*) to make sure that the governing conditions are recognized and considered.

After a thorough evaluation of the requirements of the job, the insulation fulfilling the most important requirements is selected. This is sometimes difficult; complete lists of properties are not published, and only a small number of standard tests have been accepted, so direct comparison is generally impossible. Therefore, although it is not the best engineering practice, the final selection of the material may have to be based principally on observation and experience.

The information contained in Table I may be helpful in the selection of the proper insulation to satisfy most industrial requirements. Some of this information is presented in non-technical terms and, in some cases, is based on observation. Also, some of the materials listed are produced by more than one manufacturer; the values for individual products may differ slightly from those shown.

Even the best insulation will not give good service if improperly in-

Table I—Characteristics of Thermal Insulation Materials

Materials	General Forms	Strength	Resistance to Water	Resistance to Vapor	Composition	Advantages	Disadvantages	Temp. Limits, Deg. F. Min.	Temp. Limits, Deg. F. Max.	Conductivity, Btu./(Hr.) (Sq. Ft.) (Deg. F./In.) 32	70	212	500	Density, Lb. Per Cu. Ft.
85% Magnesia	Molded and formed pipe insulation, segments and blocks	Good compressive strength; limited flexural and tensile strength	Fair	Moderate	85% hydrated magnesium carbonate	High shearing resistance; high compressive strength	Not suitable for bridging under heavy load; nonflexible	212	575		0.410	0.460		11
Hydrous Calcium Silicate	Molded and formed pipe insulation, segments and blocks	Good compressive and flexural strength; limited tensile strength	Good	Moderate	Hydrous calcium silicate blended with long asbestos fibers	High shearing resistance; high compressive strength	Not suitable for bridging under heavy load; nonflexible	100	1,200		0.400	0.450	0.540	12
Asbestos Fiber (Standard)	Processed into pipe insulation and block	Good flexural and excellent tensile strength	Excellent	Fair	Long amosite fibers blended with binders	Excellent for bridging and for use in steam tracing	Dimension variable	33	750		0.320	0.390	0.538	14
Asbestos Fiber (Super)	Processed into pipe insulation and block	Good compressive and flexural strength; limited tensile strength	Fair	Moderate	Hydrous calcium silicate blended with long asbestos fibers	High shearing resistance; high compressive strength	Not suitable for bridging under heavy load; nonflexible	212	1,200			0.42	0.56	18
Diatomaceous Earth	Molded and formed pipe insulation, segments and blocks	Good compressive strength; limited flexural and tensile strength	Fair	Moderate	Diatomaceous earth blended with long asbestos fibers	Handles well, used as inner layer under 85% magnesia where operating temperature exceeds 575 deg. F.	Not suitable for bridging under heavy load; nonflexible	22	1,900		0.66	0.720		23
Mineral Wool	Molded into blocks and lagging	Limited compressive and tensile strength; fair flexural strength	Excellent	Moderate	Mineral fibers blended with binders	Flexible and withstands considerable expansion and contraction	Will not resist excessive mechanical abuse without indentation	100	1,700		0.390	0.420	0.420	18
Glass Fibers	Felted into rolls	Soft, flexible; little compressive resistance after application	Good	Moderate	Fine glass fibers lightly bonded	Flexible; fibers respond to repeated compressing; good thermal cushioning	Pronounced depression under heavy loading	Not known	600					1
Glass Fibers	Formed into pipe insulation and block	Soft, flexible fibers; will not break down under flexing	Excellent	Moderate	Glass fibers bonded	Flexible; light fibers will not break down under moderate impact; fair tensile strength	Application limited under certain conditions	Not known	600	0.270	0.273	0.320		8
Glass Fibers	Felted glass fiber blanket with various types of facings	Soft, flexible; little compressive resistance after application	Good	Moderate	Felted glass fibers fabricated with metal mesh or other facing	Flexible, light fibers will not break down under moderate impact; fibers respond to repeated compressing	Application limited under certain conditions due to binder	Not known	1,000	0.21	0.280	0.320	0.600	6
Cement	Mineral wool-water mix; semi-thermosetting	Resistance to impact normally good	Water will soften the dried cement	Moderate	Nodulated mineral wool and asbestos fibers with inorganic binders	Good troweling characteristics; medium smooth finish; good adhesion and cohesion	Slow setting; will not stand beating rain	100	1,800		0.690	0.820	1.058	26
Cement	Mineral wool-water mix; hydraulic setting	Impact resistance very good	Will not soften when wetted	Moderate	Nodulated mineral wool and asbestos fibers and inorganic binders	Fair troweling characteristics; smooth finish, good adhesion and cohesion; quick setting	Cannot be reworked	32	1,700	0.46	0.525	0.610	0.840	49
Hairfelt	Felted into blanket roll	Standard density, very spongy; heavy density, very firm	Little resistance	Little resistance	100% cattle hair.	Excellent emergency low temperature insulation; can be formed over any size or shape pipe or vessel	Requires careful vapor treatment; depends on vapor barrier for its service in low temperatures	Not known	250	0.25	0.260			8.25 (Standard) 17.25 (Heavy)
Mineral Cork	Formed pipe insulation and blankets	Moderate compressive and tensile strength	Good	Moderate	Mineral wool fibers with asbestos binders	Easily fitted at atmospheric temperatures	Requires careful vapor treatment; depends on vapor barrier for its service in low temperatures	Not known	150	0.305	0.325			15
Mineral Wool	Semi-rigid blanket, etc., formed into pipe insulation, block and lagging	Moderate compressive and tensile strength	Fair	Moderate	Mineral wool fibers bonded	Easily fitted at atmospheric temperatures	Requires careful vapor treatment; depends on vapor barrier for its service in low temperatures	Not known	250	0.300	0.320			14
Vegetable Cork	Molded pipe insulation, blocks, lagging and fitting covers	Compressible under light load, but does support heavy loads	Good	Fair	Granulated vegetable cork bonded with natural cork resin	High vibration resistance, fair tensile strength	Should be fire-proofed in critical areas	Not known	200	0.285	0.300			11
Cellular Glass	Rigid, fabricated pipe insulation, lagging, segments and fitting covers	High compressive strength; fair tensile strength	Excellent	Excellent	Inorganic glass containing microscopic, hermetically sealed cells	Easily shaped and fitted; does not depend on vapor barrier for its vapor resistance; incombustible	Should be protected against abrasion	Not known	800	0.325	0.415			10
Wool Felt	Laminated sheets formed into pipe insulation	Good compressive and tensile strength	Moderate	Moderate	Bonded sheets of rag felt	Low cost	Not to be used in critical areas	32	225	0.510				18
Air Cell	Laminated corrugated felts formed into pipe insulation and sheets	Little compressive strength; moderate tensile strength	Moderate	Moderate	Asbestos felts cemented together	Light weight, low cost	Will not withstand severe abuse	100	300		0.490	0.550		9
Asbestos	Laminated felts formed into pipe insulation, blocks and curved segments	Little compressive strength until compressed approximately 20%; moderate longitudinal strength	Moderate	Moderate	Asbestos sheets separated by spongy cellular nodules or by indentation	Fair tensile strength	Sags and becomes soft when wet	100	700		0.390	0.450	0.560	23

stalled and if not used with accessory materials which will withstand the conditions imposed by the installation. For example, unless the securement will withstand all the stresses and corrosion factors to which it is subjected, the insulation cannot remain in place. If the weather and vapor barriers cannot withstand conditions to which they are subjected, then the insulation will likewise be damaged.

ECONOMIC THICKNESS

Fundamentally, the heat transferred through an insulation is determined by the difference between the high temperature on one side and the low temperature on the other side, divided by the resistance to heat flow. This resistance includes, in addition to the insulant itself, the outside air film and sometimes an inside air film. Methods for calculating heat flow and film resistances can be found in basic texts and handbooks.

As the thickness of thermal insulation is increased, the amount of heat loss is decreased. Of course, the thicker the insulation, the higher its cost. When the insulation is of the optimum thickness, the sum of the value of heat lost per year and the annual cost of insulation is a minimum.

For flat surfaces, McMillan gives the equation for determining the most economical thickness x in inches as

$$x = \sqrt{ak/b} - Rk$$

in which

$a = MY\Delta t/1{,}000{,}000$
b = annual cost of insulation, \$/(yr.) (bd. ft.)
k = thermal conductivity, Btu./(hr.) (ft.^{2}) (deg. F./in.)
M = value of heat, \$/million Btu.
R = sum of air-film resistances, (hr.) (ft.^{2}) (deg. F.)/Btu.
Δt = difference between inside temperature and ambient air temperature, deg. F.
Y = operating time, hr./yr.

The first term on the right expresses in inches of thickness the total thermal resistance required. The second term reduces this total by the equivalent thickness of the air-film resistances.

For cylindrical surfaces, such as pipes, the equation must be corrected for the difference between the inside and outside surface areas of the insulation. On the basis of outside area, the thickness x is replaced by the term $r_2 \ln(r_2/r_1)$, where r_1 is the inside radius and r_2 the outside radius.

However, most pipe insulation is sold on a linear foot basis rather than an area basis. In the derivation of the minimum cost equation via differentiating and equating to zero, this change in cost basis gives rise to an additional factor not appearing in the equation for flat surfaces.

The final expression for economic thickness for cylindrical surfaces is

$$\left(r_2 \ln \frac{r_2}{r_1} + R_s k\right) \sqrt{\frac{2\,r_2 - r_1}{r_2 - R_s k}} = \sqrt{ak/b}$$

where R_s is the air-film resistance of the outside surface and b is expressed on the basis of outside surface area.

OTHER THICKNESS REQUIREMENTS

It would appear that the economic factor in calculating insulation thickness would be the most acceptable method. However, this is not necessarily true in chemical process operations.

Consideration of the allowable loss or gain in process heat, regardless of the cost of the heat (or refrigeration) involved, is of major importance. If an operating process can afford to lose or gain only a limited amount of heat, or if certain vessels operate on definite temperature limitations, a sufficient thickness of insulation must be provided to maintain the required conditions.

Safety is also a factor. For high-temperature operations, insulation designed on a purely economic basis might operate with such a hot surface that operating personnel would be in danger of getting burned. Another consideration is that the higher the surface temperature the greater the hazard of flashing from flammable materials of low flash points.

Most outside insulation is protected with bituminous saturated felts or mastics composed of bituminous bases. Indoor insulation is usually finished by painting. In either case, unless the surface temperature is sufficiently low to prevent the heat from shortening the life of these materials, the cost of maintaining the outer finish will be prohibitive.

Surface temperature of insulation on low-temperature equipment and piping should normally be above the dewpoint of the ambient air. Under extremely humid conditions it is virtually impossible to prevent occasional condensation on low-temperature insulation surfaces. However, the insulation should be designed so that the periods when condensation occurs will be relatively infrequent and of short duration.

If the surface temperature stays below the average dewpoint it will always be wet. Migration of moisture is much faster through a wet surface than through a dry surface which is above the dewpoint. Not only will the drip from wet surfaces cause considerable damage to surrounding metal, but the life of the barrier and the insulation itself will also be decreased.

REFLECTIVE INSULATION

In some applications reflective insulation can be used to greater advantage than any mass-type insulation. One particular characteristic which may be of importance is that it has low heat-storage capacity as compared with mass insulation.

However, industrial applications of reflective insulation have been relatively infrequent up to the present time. To a great degree this is due to a lack of knowledge regarding this type of insulation.

Reflective insulation consists of one or more parallel sheets of metal separated by suitable spacers. By restricting the air movement, heat transfer by convection is cut to a minimum. Heat will pass through air or any other gas by conduction, as it does through a solid; however, the conductivity of air is low, being only 0.16 Btu. per (hr.) (sq. ft.) (deg. F. per in.) at 70 deg. F. mean temperature.

The balance of the total heat loss is transferred by radiation. The amount transferred from a warmer surface to a cooler one is determined by the temperature difference between the two surfaces, the emissivity of the warmer surface and the reflectivity of the cooler surface. By using a material on the warm side which has a low emissivity and a material on the cool side which has a high reflectivity, the amount of heat transferred by radiation will be minimized.

Although many polished metals have low emissivity and high reflectivity, when they lose their polish their emissivity values rise and their reflectivity values drop. Aluminum is frequently used in reflective insulation because the change from a polished surface to an oxidized surface increases its emissivity and reduces its reflectivity only about 5 percent.

USE OF VACUUM

If the air is removed from between two surfaces which have low emissive and high reflective values, then the heat transfer by convection and conduction will be reduced to a much smaller amount than when air is present. The vacuum also assists in retaining the most efficient reflective surfaces; thus, heat transfer by radiation is minimized. For example, a bright polished silver surface is one of the best reflective surfaces when used in an evacuated space, with no oxygen present to dull the shiny surface.

Use of reflective surfaces separated by a vacuum is a very efficient means of insulating thermally, but because of the difficulty of maintaining a vacuum it is generally restricted to the insulation of relatively small vessels or objects. It is excellent at low temperatures, providing the vacuum is maintained, because the system is also vapor-tight. Vacuum used for high temperatures is generally limited by the restrictions imposed by the container—by its ability to resist thermal shock or elevated temperature.

Table II—What to Consider When Comparing Insulation Materials

- Dimensional properties
  - Shapes and sizes
    - Straightness
    - Smoothness
  - Shrinkage—excessively large voids
  - Coverage
  - Density
- Thermal properties
  - Conductivity
    - Effect of temperature
    - Effect of moisture
    - Effect of joints
    - Effect of tie-wires, etc.
  - Specific heat
    - Effect of temperature
    - Effect of moisture
  - Thermal diffusivity
  - Thermal emissivity
  - Thermal absorptivity
  - Temperature range—maximum and minimum
  - Expansion and contraction
  - Resistance to flame
- Mechanical properties
  - Compression strength
  - Compressibility of blanket or fill materials
  - Tensile strength
  - Flexural strength
  - Impact strength
  - Compression—shear strength
  - Hardness—surface
  - Abrasion resistance
  - Indentation strength
  - Tearing strength of blanket and sheets
  - Loss of strength because of fatigue
  - Folding endurance of sheets and films
  - Resistance to thermal shock
  - Temperature effect on strength
- Moisture properties
  - Water migration
  - Vapor migration
  - Vapor migration through joints, cracks, tape, etc.
  - Effect of temperature, humidity and air motion on vapor migration
  - Relation of thickness resistance to vapor migration
  - Relation of vapor barriers to thermal insulation in their ability to be used together
- Chemical properties
  - Chemical analysis
  - Corrosive properties—alkalinity, pH
  - Corrosive properties in combination with other materials
    - With moisture present
    - With process chemicals present
  - Smoke point—alone or with chemicals present
  - Flash point—alone or with chemicals present
  - Auto-ignition point—alone or with chemicals present
- Electrical properties
  - Resistance to electrical flow, dry, wet
  - Galvanic action
- Workability properties
  - Cutting characteristics of solids
  - Fitting characteristics of solids
  - Forming characteristics of solids
  - Adhesive characteristics of cements and mastics
  - Pouring characteristics of cements and mastics
  - Troweling characteristics of cements and mastics
  - Brushing characteristics of mastics
  - Handleability of material
  - Personnel reaction—effect on skin
  - Toxic hazard of application—solvents in mastic, etc.

FOR EXTREME LOW TEMPERATURES

Insulation of low-temperature surfaces presents an additional problem from that of high temperatures—moisture may enter the insulation.

All outdoor insulation, on either hot or cold surfaces, must be protected by a weather barrier to prevent the insulation from becoming soaked with water. Moisture in the vapor form must also be prevented from entering the insulation on low-temperature jobs.

The low temperature of the inner surface of the insulation causes an area of lower vapor pressure than that of the atmosphere. Water vapor, in attempting to equalize this pressure difference, tries to diffuse into the insulation. At some point in its inward travel it reaches its dewpoint and condenses. Continuation of the process eventually fills the voids in the insulation with water or ice. Completely saturated insulation has a conductivity value of 4.0, compared with about 0.25 for dry insulation. Thus the heat flow through the insulation will increase up to 16-fold.

Unless the insulation is itself vapor-resistant the vapor barrier becomes of paramount importance in protecting the insulation and providing an economical service life. Vapor barriers may be composed of any one or more of a number of materials; these materials must be selected for their ability to serve the requirements of the installation in question.

A vapor barrier should completely seal the entire insulation surface. One common mistake in the use of vapor barriers is the omission of tie-offs. At intervals the barrier should be sealed off through the insulation to the metal surface. In case the outer membrane is punctured such tie-offs will restrict vapor migration to only one sealed section. For the same reason, where pipe insulation is interrupted at a junction point, such as an ell, valve or flange, the vapor barrier of the pipe insulation should be sealed off from the insulation and vapor barrier of the fitting.

Breakdowns of weather and vapor barriers frequently begin at corners, particularly inside corners. For this reason it is preferable to maintain as large a radius as possible and avoid

sharp acute angles by rounding out inside corners, using special precaution that the barrier is well reinforced and installed with particular care at these points. Where a vapor-resistant insulation is used the considerations are somewhat less exacting.

The weakest point of any insulation lies in the joints. Unless joints are adequately sealed and protected, moisture will enter at these points. The moisture may then alternately freeze and thaw and eventually cause complete breakdown of the insulation. With extremely low-temperature surfaces, care must be taken that the materials used for sealing do not freeze and crystallize at the temperatures to which they are subjected. A frozen sealing material will fracture the insulation the same as ice.

Expansion and contraction of pipes and vessels should be carefully considered in the design of insulation. On low-temperature installations such movements transmitted to the vapor and weather barriers contribute to their breakdown; wherever possible, these stresses should be eliminated or compensated for in the design.

The problems of thermal insulation are becoming more complex and severe as process temperature ranges are extended and economic requirements become more critical. Thermal insulation has become a science as well as an art and in the future will demand more careful engineering than in the past.

JAMES J. CARBERRY was the author of a stimulating article in our September 1952 issue on the dimensionless groups **used in heat-transfer correlations. His** approach in evaluating heat-transport media in the following article follows similar fundamental lines.

A native of Brooklyn, the author was graduated from the University of Notre Dame in 1951 with an M.S. degree in chemical engineering. For the past two years he has been employed by Du Pont at its Eastern Laboratory, Gibbstown, N. J. He previously served in the Navy.

His professional interests center about the subject of rate processes, including kinetics and heat and mass transfer. He is a junior member of AIChE.

Among his other interests are philosophy, history and music.

Media for Heat Transport

Heat-transfer coefficient vs. pumping energy provides a rational basis for evaluation of transport media.

Many processes involving heating or cooling require the use of an intermediate agent for transport of the heat (or cold) between the process and the heating source or sink. Steam, air and water are, of course, the most common agents so used. In recent years, however, other liquids, gases and vapors, even liquid metals, have found increasing use as heat-transfer media.

A number of considerations enter into the selection of the most suitable medium for a given heat-transport application. Among these are cost, availability, vapor pressure, freezing point, corrosiveness, toxicity—all properties of the medium itself—and the capital and operating costs of the transport system.

LIQUID, GAS OR VAPOR?

Air and other so-called permanent gases can be used over nearly the entire range of industrially important temperatures. However, such gases are poor heat-transfer media, requiring the expenditure of large amounts of pumping energy per unit of heat transported. Condensing vapors and boiling liquids, on the other hand, show much better heat-transfer coefficients than do gases (see table below).

Geiringer[2] presents some compelling arguments in favor of liquid heat-transport systems over systems using vapors and gases. Liquid systems are said to be better adapted to surface temperature uniformity, close temperature control, and alternate heating and cooling processes.

Usual Ranges of Film Coefficients[6]

Steam, dropwise condensation	10,000—20,000
Steam, film-type condensation	1,000—3,000
Boiling water	300—9,000
Condensing organic vapors	200—900
Steam, superheating	5—20
Air, heating or cooling	0.2—8

NOMENCLATURE

A	Surface area, ft.^{2}
C, C'	Constants
c_p	Specific heat, Btu. per (lb.) (deg. F.)
D	Diameter, ft.
E	Energy loss per unit surface area, (ft.-lb. per hr.) per ft.^{2}
f	Friction factor
G	Mass velocity, lb. per (hr.) (ft.^{2})
g_c	Gravitational constant, ft. per hr.^{2}
h	Heat-transfer coefficient, Btu. per (hr.) (ft.^{2}) (deg. F.)
j_H	Heat-transfer factor
k	Thermal conductivity, Btu. per (hr.) (ft.^{2}) (deg. F. per ft.)
Pr	Prandtl number
Δp	Pressure drop, lb. per ft.^{2}
Re	Reynolds number
S	Cross-sectional area, ft.^{2}
μ	Viscosity, lb. per (hr.) (ft.)
ρ	Density, lb. per ft.^{3}

LIQUID-PHASE HEAT TRANSFER

The character of the individual film coefficient of heat transfer h is known to be a function of fluid viscosity μ, heat capacity c_p and thermal conductivity k; these properties are combined in the dimensionless Prandtl number $\mu c_p/k$. The magnitude or "thickness" of the film is a function of the geometry and fluid dynamics of the system, hence of the Reynolds number DG/μ.

For turbulent flow in circular tubes and pipes the film coefficient may be expressed by the Chilton-Colburn relation

$$h = 0.023\ \mathrm{Re}^{-0.2}\ \mathrm{Pr}^{-2/3}\ c_p G \quad (1)$$

where, according to the heat-momentum transfer analogy,

$$0.023\ \mathrm{Re}^{-0.2} = j_H = f/2 \quad (2)$$

Obviously, a high coefficient is favored by low viscosity and high flow rate, thermal conductivity and heat capacity. However, a comparison of heat-transfer media must be made on an economic basis. Colburn[1] states that h must be correlated with E, the

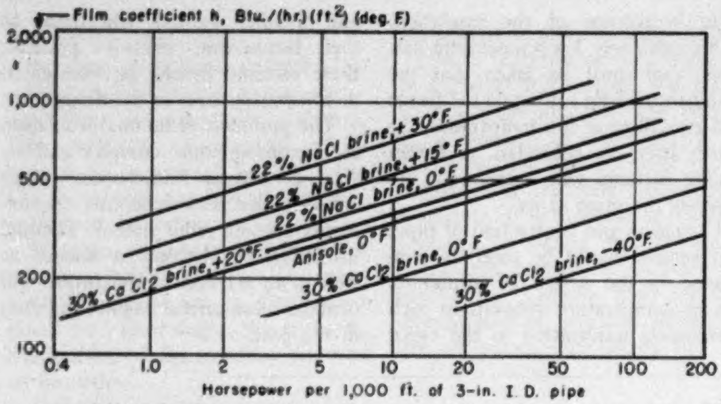

Fig. 1—LOW-TEMPERATURE media, film coefficient vs. power requirement.

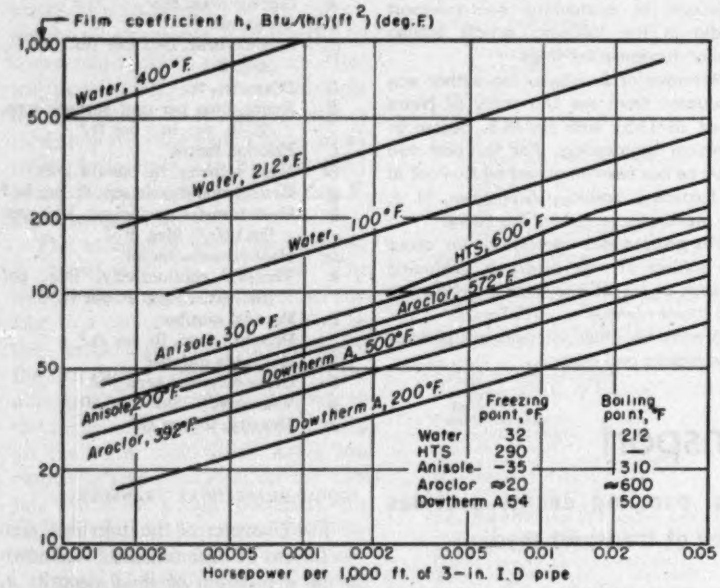

Fig. 2—MIDDLE temperature range, film coefficient vs. power requirement.

frictional energy expended per unit surface area of pipe.

Recalling that in turbulent flow the friction factor f is related to pressure drop Δp by

$$f = 2g_c \, \Delta p \rho S/G^2 A \qquad (3)$$

and power loss per unit of surface area E is given by

$$E = \Delta p G S/\rho A \qquad (4)$$

then

$$f = 2g_c E \rho^2/G^3 \qquad (5)$$

or

$$E = fG^3/2g_c \rho^2 \qquad (6)$$

In turbulent flow,

$$f/2 = 0.023/(DG/\mu)^{0.2} \qquad (7)$$

Therefore,

$$E = C(\mu/D)^{0.2}\, G^{2.8}/\rho^2 \qquad (8)$$

$$\text{where } C = 0.023/g_c.$$

The power expended is thus a direct function of mass velocity and, to a small extent, viscosity, while a high density favors low power loss.

Eliminating G between Eqs. (1) and (8) we obtain

$$h = C'E^{2/7}/D^{1/7} \qquad (9)$$

where C' is a function of Pr and ρ and thus is constant for a given fluid at a given temperature and pressure.

Values of the film coefficient h have been calculated and correlated with the horsepower loss per 1,000 ft. of 3-in. I.D. pipe for various fluids at several temperature levels. The Chilton-Colburn relation is employed for fluids of Pr = 0.5 to 30 (brine solutions, anisole, water, Aroclor, Dowtherm A). The data for Hitec (HTS) are those data obtained and correlated as hD vs. DG by Kirst, Nagle and Castner.[4] For mercury, sodium and the sodium-potassium media, the Martinelli relation as simplified by Lyon[5] was employed. The Lyon equation is

$$h = k/D\,[7 + 0.025\,(\alpha \text{ Re Pr})^{0.8}] \qquad (10)$$

For Reynolds numbers greater than 10^6, the film coefficient for molten metals varies as the 2/7 power of E, as is the case with the more common fluids.

The correlations apply only to turbulent flow in commercial pipe.

LOW-TEMPERATURE MEDIA

In Fig. 1 are shown the film coefficient-power requirement curves for two brine solutions and anisole. In computing E for the brine solutions, the data of Shields were used.

Sodium chloride brines, though cheaper than calcium chloride, are useful only to temperatures down to −6.03 deg. F., the 22 percent solutions forming a eutectic in this region. There are corrosion hazards involved in using brine solutions. $CaCl_2$ solutions tend to precipitate solids when used with untreated water, though permitting operation at lower temperatures than is possible with NaCl brine.

In general, brine coefficients decrease with an increase in salt concentration and, therefore, with decreasing temperature limit. Fig. 1 illustrates this point. Convenient charts for rapid determination of brine physical properties and heat-transfer factors have been published by Shields.[6] Such data, when correlated on the basis of h vs. E, allow one to make a more judicious choice of cooling medium.

Anisole (methoxybenzene) has recently been proposed as a heat-transfer medium. It may be used with mild steel, and tests indicate that the compound exhibits high thermal stability. Anisole freezes at −35 deg. F., and on the basis of the correlation in Fig. 1 it appears to be potentially competitive as a coolant. The viscosity of anisole was found to vary linearly with absolute temperature on logarithmic coordinates. The curve for anisole at 0 deg. F. is thus based upon an extrapolation of viscosity data. The correlation at −20 deg. F. would be only slightly below that at 0 deg.

Since these data are based upon extrapolations the true significance is questionable until verified experimentally and economically.

MIDDLE TEMPERATURE RANGE

Within the range of 40 to 400 deg. F., operating pressure as well as the power-heat transfer relation must be considered. Liquid water is obviously a superior medium in this temperature range (see *Fig.* 2). However, pressures in excess of 250 psi. are required in order that capital be made of the excellent power-heat transfer relationship for liquid water. Geiringer[8] notes that European heating plants employ liquid water at pressures approaching 2,800 psi. Smaller pipes can be used than those required with steam. Traps become unnecessary, and lines need not be run with particular regard to pitch. Radiation losses are minimized, which makes it more practical to transport heat over great distances.

Dowtherm A (73.5 percent diphenyl oxide, 26.5 percent diphenyl) is primarily employed as a condensing vapor, and though its heat of vaporization (125 Btu. per lb.) is low compared with that of steam, atmospheric-pressure operation can be realized at 500 deg. F. As a liquid, Dowtherm finds use in heating-cooling cycles as frequently found in batch reactor systems. It freezes at 53.6 deg. F. Packaged Dowtherm units are available and represent convenient means of efficient low-pressure heat transport.

Anisole may find uses like those to which Dowtherm is put. In the liquid state, it is apparently superior up to 300 deg. F. (b.p. 310 deg. F.), as shown in Fig. 2. Anisole can be easily pumped at room temperature. The heat of vaporization of anisole is 154 Btu. per lb., higher than that of Dowtherm. Where a vapor system is desired, anisole under pressure fills the gap between 150-psi. steam and 500 deg., whereas a Dowtherm vapor system in this range would have to operate under vacuum.

Aroclor 1248 (Monsanto Chemical Co.) is a noncombustible heat-transfer medium suitable for use as a liquid at temperatures up to 600 deg. F. This chlorinated biphenyl is one of the best media in the range of 400 to 550 deg. Like anisole, Aroclor can be easily pumped at room temperature. It is reported that Aroclor is practically noncorrosive to nearly all metals, including cast iron, steel and bronze.[7]

Geiringer[8] reports that tetraryl

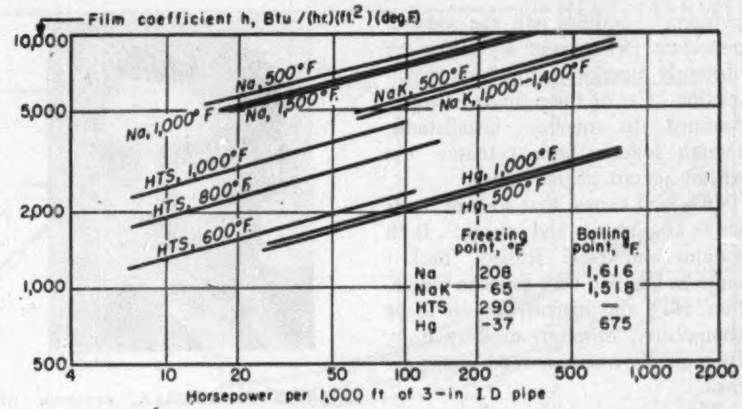

Fig. 3—HIGH-TEMPERATURE media, film coefficient vs. power requirement.

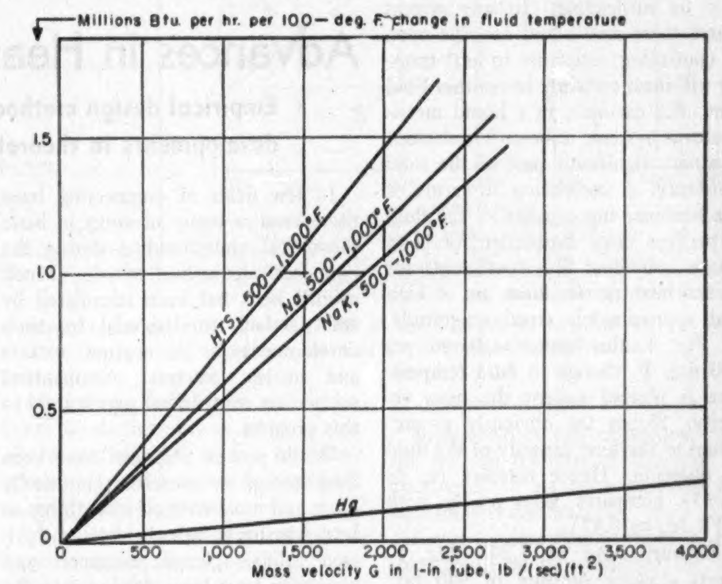

Fig. 4—HIGH-TEMPERATURE media, heat-carrying capacity at given velocity.

silicate has properties which make it an ideal heat-transfer medium. It is a liquid from −40 deg. to 700 deg. F. Production is stated to be small at this time, hence its price is higher than that of the more common media. Pertinent data are not available for this silicate, hence its power vs. heat-transfer characteristics were not calculated.

In Fig. 2 is shown also the *h* vs. *E* relationship for Hitec heat-transfer salt (HTS) at 600 deg. F. HTS is a 50-50 mixture of sodium nitrite and potassium nitrate which melts at 282 deg. F., or a 40-7-53 mixture of sodium nitrite, sodium nitrate and potassium nitrate melting at 288 deg. F.

Packaged HTS units are available. HTS affords an excellent means of obtaining the uniform high temperatures required in certain distillation and reactor systems.

Not included in the correlations because of a lack of physical data is Hydrotherm 800, a phenolic compound. It is reported by American Hydrotherm Corp. to be a promising medium. Hydrotherm 800 boils at 875 deg. F. and shows no tendency to crystallize even at −60 deg. F. Excellent thermal stability is said to be the most striking feature of Hydrotherm 800.

HIGH-TEMPERATURE MEDIA

In the high temperature range (600-1,400 deg. F.) molten salt and metals are obvious candidates for consideration. In Fig. 3 are shown the power loss-heat transfer relationships for HTS, mercury, sodium and sodium-

potassium. Sodium and the sodium-potassium (44 percent K) media are obviously superior on this basis of correlation. Use of these fluids is largely confined to nuclear installations, though sodium finds extensive use within aircraft engine valves.

It is well known that sodium reacts with air, water and steam. Both sodium and NaK (called "nack") must be handled with extreme precaution. HTS and mercury appear to be competitive; however, mercury is by far more expensive, and its vapors are toxic.

The extremely high coefficients obtained with HTS, Na, NaK and Hg may be misleading. In any system where these media find use, the overall controlling resistance to heat transfer will most certainly be another fluid film. For example, in a liquid metal-to-steam system, tube-wall resistance is a very significant part of the total resistance. A correlation in terms of the heat-carrying capacity of the fluid is perhaps more instructive for cases where individual film coefficients for several heat-transfer fluids are of high and approximately equal magnitude. In Fig. 4, the heat transferred per 100 deg. F. change in fluid temperature is plotted against the mass velocity. Slopes are obviously proportional to the heat capacity of the fluid in question. Hence mercury ($c_p \cong 0.033$) compares very poorly with HTS ($c_p \cong 0.37$).

Mercury used at 1,200 deg. F. exerts a vapor pressure of 500 psi., while HTS has no appreciable vapor pressure in this range. Many important details relating to operation and performance of an HTS unit have been published.[7,8]

For operation above 1,200 deg. F. Na (b.p. 1,616 deg. F.) and NaK (b.p. 1,518 deg. F.) may be employed. For higher temperatures lead (b.p. 3,170 deg. F.) and the lead-bismuth eutectic (b.p. 3,038) are available.

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Jan Bardeu

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He is consultant to the Knolls Atomic Power Laboratory, Brookhaven National Laboratory, and Pratt & Whitney Aircraft. He is currently co-authoring and editing a forthcoming McGraw-Hill book on nuclear engineering.

Prof. Bonilla is very active in the work of professional societies. He is the present chairman of the Middle Atlantic section of the ASEE and is a member of committees of AIChE, ASME and ASEE on heat transfer and related fields.

His home is in Tenafly, N. J.

Advances in Heat Transfer

Empirical design methods are being reinforced by recent developments in theoretical knowledge.

In few fields of engineering have there been as many advances in basic theoretical understanding during the past decade as in heat transfer. Much of this work has been stimulated by and, in fact, fundamental to, such developments as jet engines, rockets and nuclear reactors. Aeronautical science has contributed significantly to this progress.

While process engineers have been busy trying to correlate empirically more and more data on such things as heat transfer to tube banks and fluidized solids, research engineers and physicists have been delving into the problems of heat transfer involving high velocities, liquid metals and unsteady state. Even the mathematicians have contributed significantly in new methods for solving complex problems.

ANALOGIES WITH FLUID FLOW

A theoretical approach that has received a lot of attention lately is the utilization of information on velocity distribution and turbulence to predict and correlate heat-transfer coefficients of fluids in turbulent flow. This has been applied particularly to molten metals, as well as to other fluids at high velocities or high heat fluxes. In such cases the physical properties vary widely across the stream.

The analysis has usually started with the generalized isothermal velocity distribution across the channel (Fig. 1) originally proposed by von Karman.[28] This includes the theoretical purely laminar sublayer and the two empirical straight lines shown.

Several defects exist in this distribution: (a) There are not yet enough experimental data to show whether the flow actually is entirely laminar over the range $0 < y^+ < 5$; (b) in deriving the laminar sublayer formula the shear stress across it was assumed constant, which makes the curve too high at low Reynolds numbers; (c) there should undoubtedly be no discontinuities in the first or second derivatives, as there are at $y^+ = 5$ and 30; and (d) the straight turbulent core line shown is inaccurate near the center, since it is actually the locus of points near the wall for many runs and neglects the leveling off of the velocity near the center for any one run. However, these defects are unimportant under most conditions, and very helpful predictions of heat-transfer coefficients have been obtained by this method.

Other isothermal velocity distribution laws have been proposed. Though gaining in smoothness, they tend to become more difficult to manipulate mathematically. Deissler's analysis[7] differs from von Karman's principally in that turbulence is assumed to penetrate all the way to the wall, being directly proportional near the wall to the local velocity and to the distance from the wall. Deissler is thus able to include von Karman's streamline and buffer layers in a single formula, as does Rannie.[23] Two other relations[19,20]

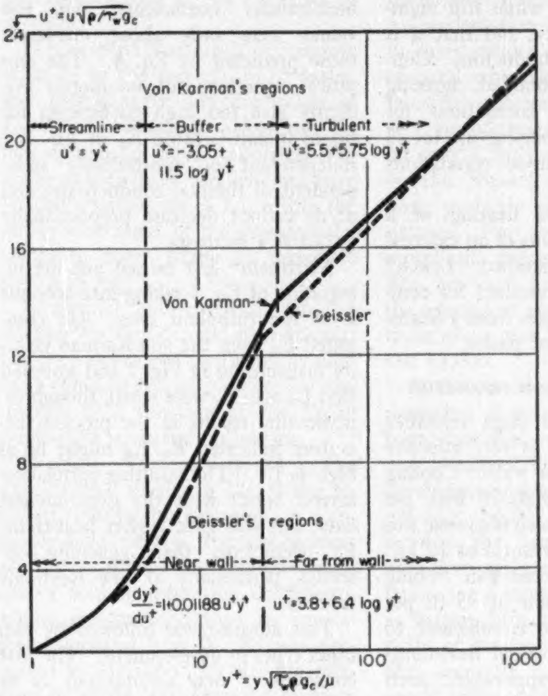
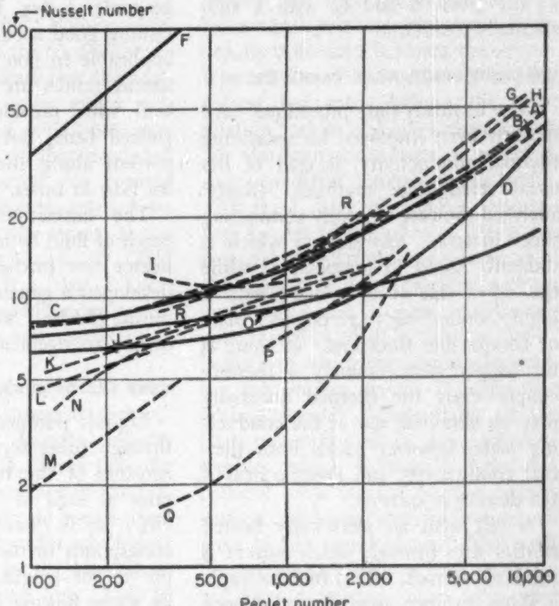


Fig. 1—**ISOTHERMAL** velocity distribution curves, according to von Karman and Deissler.



Key: (W=wetted, U=unwetted) A=Martinelli, Pr 10^{-3}; B=Pr 10^{-3}; C=Lyon; D=Deissler; E=Kennison; F=Colburn, Pr 0.027; G=Isakoff-Drew, U, x/d 58; H=x/d 138; I=Untermeyer, W; J=Johnson et al, 1951; K=Trefethen, W & U; L=Doody-Younger, W; M=U; N=English-Barrett, U; O=Johnson et al, 1950; P=Lubarsky, U; Q=Untermeyer, U; R=Werner-King-Tidball, W.

Fig. 2—**HEATING** of liquid metals in turbulent flow; A to F, theoretical relations; G to R, experimental results.

instead combine the buffer and turbulent regions into one formula.

In any case, the generalized velocity distribution curve or equation can be used to compute the eddy viscosity E_M as a function of radius by means of

$$\begin{aligned} \tau g_c &= \tau_w g_c\,(1 - y/r) \\ &= (\mu + E_M\rho)\, du/dy \end{aligned} \qquad (1)$$

and thus:

$$\frac{E_M\rho}{\mu} = \left(1 - \frac{y^+}{r^+}\right)\frac{dy^+}{du^+} - 1 \qquad (2)$$

NOMENCLATURE

c	Specific heat
C_D	Drag coefficient
D	Diameter
E_H	Eddy conductivity
E_M	Eddy viscosity
E_V	Eddy diffusivity of vorticity
f_F	Fanning friction factor
g	Acceleration of gravity
g_c	Ratio of absolute system mass unit to actual system mass unit
Gr	Grashof number, $D^3\rho^2 g\beta\Delta t/\mu^2$
h	Film heat-transfer coefficient
k	Thermal conductivity
Nu	Nusselt number, hD/k
Pe	Peclet number, $Du_b\rho c_p/k$
Pr	Prandtl number, $c_p\mu/k$
q/A	Heat flow density
r	Radius
r^+	$r(\tau_w g_c\rho)^{1/2}/\mu = \mathrm{Re}(f_F/8)^{1/2}$
Re	Reynolds number, $Du_b\rho/\mu$
t	Temperature
Δt	Heat-transfer driving force
T	Absolute temperature
u	Local velocity
u^+	$u(\rho/\tau_w g_c)^{1/2}$
w	Mass flow rate
y	Distance to wall
y^+	$y(\tau_w g_c\rho)^{1/2}/\mu$
β	Coefficient of volumetric thermal expansion
μ	Viscosity
ρ	Density
τ	Shear stress

Subscripts

a	At wall with no heat transfer
b	Average of stream
f	Film (average as required)
p	Constant pressure
v	Constant volume
w	At wall
x	Local value

In the two wall layers, and sometimes in all three zones, y^+/r^+ is usually neglected, and in the turbulent core the second 1 is usually neglected, as previously suggested.

Since E_M is a "geometrical turbulence," presumably affected only by the average flow and range of the eddies, as a first approximation it is reasonable to assume that it equals the E_H for heat transfer in the corresponding expression

$$q/A = (k + E_H\rho c_p)\,(dt/dy) \qquad (3)$$

Integration of this expression from the wall to the axis of the pipe or duct leads to an expression for the heat-transfer coefficient.

For streamline flow in tubes at constant wall heat flux Deissler[8] has calculated by a process of iteration the velocity and temperature distribution, friction factor and Nusselt number for gases and for liquid metals when the physical properties change appreciably with temperature.

For gases he assumed that viscosity is proportional to $T^{0.68}$. He found that the pressure gradient may be computed quite closely by Poiseuille's law if one uses the viscosity at a film temperature t_f equal to 58 percent of the wall temperature t_w and 42 percent of the mixing cup temperature t_b. Similarly, he obtained the theoretical long-pipe isothermal Nusselt number of 4.364 by taking the thermal conductivity at 1.27 t_b − 0.27 t_w.

For liquid metals, assuming μ proportional to $T^{-1.6}$, he found Poiseuille's law to hold if μ is taken at 0.54 t_w + 0.46 t_b. For metals the isothermal Nu should be multiplied by

$(\mu_b/\mu_w)^{0.14}$ to obtain the actual Nu at any given t_b and t_w with k substantially constant.

UNSTEADY-STATE HEAT TRANSFER

New unsteady-state procedures have recently been employed for measuring thermal conductivity, instead of the usual steady-state methods. Beatty[1] analyzed the case of poorly conducting sheet material, one side of which is suddenly raised in temperature while the other side is in contact with a highly conducting (e.g., copper) plate of comparable thickness. If there is no copper plate—merely a thermocouple—only the thermal diffusivity may be obtained; use of the conducting plate, however, yields both thermal conductivity and specific heat if the density is known.

A cell with an electrically heated central wire through which current is suddenly started, with a thermocouple a short distance away, has also been mathematically analyzed.[8] This arrangement, with runs lasting less than 1 min., has yielded absolute values of thermal conductivity for many liquids with an error under 2 percent.

A promising method for gases[12] involved suddenly heating a metal tube by a heavy instantaneous electrical discharge along it and observing the rise of contained gas pressure with time. It was found not to be an absolute method because of its dependence on an unknown specific heat intermediate between c_p and c_v. Another method, in which alternating current is passed through a hot wire and the amplitude and lag of the temperature wave of the wire is measured, is being studied at Columbia University for possible use at high gas temperatures without a radiation correction.

A method was recently presented[11] of determining film coefficients of heat transfer by passing through the equipment a stream of fluid having a slow sinusoidal variation of temperature with time. At the outlet of the equipment under test the stream temperature wave shows a time lag and a decrease in amplitude. The latter effect was employed.

This method, which is analogous to the frequency response technique used by instrument engineers, has been developed for surfaces of both high and low thermal conductivities. Evident advantages are that no surface temperatures need be determined, that the temperature amplitudes can be under 1 deg. F. while still maintaining good accuracy, and that it is applicable to poor conductors. Consistent results are obtained, agreeing well with previous correlations for packed beds, but ranging up to 25 percent above the usual correlations for flow in tubes.

The unsteady-state heating of a batch of fluid by means of an external heater was further studied. Lynch[22] developed a general method for computing the heat transfer from a heater of any arrangement of passes.

HEAT TRANSFER AT HIGH VELOCITIES

Liquids pumped at high velocities through tubes serve as very effective coolants of the tube walls. Cooling rates as high as 5,000,000 Btu. per (hr.) (sq. ft.) have been obtained; this corresponds to the removal of 10 kw. per in. of length from ⅛-in. tubing by water flowing inside at 35 ft. per sec. When pressure is sufficient to prevent boiling, the usual heat-transfer correlations are applicable,[18] such as:

$$\mathrm{Nu}_b = 0.023\ \mathrm{Pr}_b^{0.4}\ \mathrm{Re}_b^{0.8} \tag{4}$$

Gases flowing in tubes approximately obey the same correlations, even at supersonic velocities. For instance, McAdams[27] obtained heat-transfer coefficients averaging some 18 percent higher than Eq. 4 with air up to the velocity of sound.

With all fluids at high velocities the temperature difference causing heat transfer must be taken as $t_w - t_{aw}$, where t_{aw} is the temperature the wall would reach at the given fluid velocity with no heat transfer; it is higher than t_b because of frictional heating. It may be directly obtained by experiment, or computed by adding to the bulk temperature an expression converting frictional energy into temperature rise.

Rubesin and Johnson[30] have recently reviewed the available theories on skin friction at a flat plate parallel to air flowing at Mach numbers up to 10. They show that the local value of Nusselt number may be calculated readily from an experimental or theoretical value of the local drag coefficient C_D by the relation:

$$\mathrm{Nu}_x = 0.5\,(C_D)_x\,\mathrm{Re}_x\,\mathrm{Pr}^{1/3} \tag{5}$$

HEAT TRANSFER TO LIQUID METALS

The first heat-transfer tests with metals flowing in tubes yielded high heat-transfer coefficients, but the values were only about one-tenth those predicted by Eq. 4. The empirical equations for nonmetals evidently give too high coefficients for liquid metals because E_H in Eq. 3 is independent or substantially independent of thermal conductivity, and dt/dy cannot decrease proportionally as fast as k increases.

Martinelli[26] first carried out the integration of Eq. 3 taking into account k in the turbulent core. He computed E_M from the von Karman velocity distribution in Fig. 1 and assumed that E_H and E_M were equal, though experimental results in the previous literature indicated E_H/E_M might be as high as 1.6. The resulting correlation agreed better with the experimental data, but still gave higher heat-transfer coefficients than generally observed, particularly at low Reynolds numbers.

This advance was followed by two other types of development. The first consisted of new assumptions as to mechanism. Deissler[9] subtracted from the eddies heat they might transfer to the fluid bordering their path, obtaining for liquid metals an appreciably lower value of Nusselt number and better agreement with the average of the observed results. According to his theory the ratio E_H/E_M varies from 0.000153 Pe at low values of Peclet number asymptotically towards 1.0 at high Pe and is independent of position in the pipe.

In another direction, Kennison[19] has assumed a constant value of 0.8 for the ratio E_H/E_V, where E_V is the eddy diffusivity of vorticity or rotational momentum. The agreement with liquid metal results is good, but poor for nonmetals.

The other development consists of additional experimental determinations of E_H and E_M. Page *et al.*[29] for air in a flat duct found E_H/E_M to increase on approaching the walls, and to decrease from an average of about 1.3 at a Reynolds number of 9,000 to about 1.08 at 53,000. In their work[28] E_H/E_M always exceeded 1.

Isakoff and Drew[15] for mercury in a pipe, in the only measurements of E on a liquid metal, also found E_H/E_M to increase towards the wall. However, their value of this ratio was much lower and increased with higher Reynolds numbers, averaging 0.5 or

less for Page's range of Reynolds numbers and reaching 0.9 to 1.6 at Re = 370,000.

It is evident that much uncertainty exists as to the mechanism of turbulent heat transfer and the values of E_H that are obtained. However, the new approaches have stimulated considerable activity in the field and have yielded relations which fall within the rather wide range of the experimental values to date. Many of these are shown in Fig. 2.

A simpler semi-empirical type of relation for liquid-metal heat transfer has been developed by Lyon[24] by adding a constant Nusselt number for conduction to a function of the Peclet number to represent turbulence.

Wetting—The wide spread in the experimental results in Fig. 2 has received considerable attention. A commonly held view is that non-wetting of the wall by the molten metal causes low heat-transfer coefficients. Under certain conditions an equivalent interfacial $h = 0.1$ Re was estimated by Harrison[18] for flowing mercury in nickel, and stagnant mercury against unwetted steel gave interfacial h values[3] ranging from 150 to 1,500, rising as high as 4,000 when some sodium was added.

However, there seems to be no significant tendency for the results in Fig. 2 to group themselves according to their authors' opinions as to whether wetting occurred. A recent suggestion[20] is that the low results are due to gas bubbles entrained from the expansion chamber.

Natural Convection—A satisfactory correlation for natural convection heat transfer to molten metals as well as to other fluids has been developed,[14] as represented by:

$$Nu = 0.539 \frac{(Gr \times Pr^2)^{1/4}}{(0.952 + Pr)^{1/4}} \quad (6)$$

It was found that eddies develop downstream of the cylinder at a critical value of 11.2 ft.[-3] for the ratio $(Gr \times Pr/D^3)$. Considerably higher fluxes can then be dissipated as the eddying wake continues to spread, with no appreciable change in Δt. This situation, which can be encountered with any liquid at high enough heat flux, is of interest because of the high heat-transfer coefficients possible and potential control difficulties. For instance, if the heating is by steam under pressure control, wide fluctuations in steam demand might occur at the critical temperature difference from steam to bath.

Condensation and Boiling—Preliminary results on the condensation of metal vapors[8] indicate that the heat-transfer coefficient under either wetting or non-wetting conditions may be only a fraction of that predicted by the Nusselt theory[31] for laminar flow, probably owing to contact resistance. For mercury vapor at atmospheric pressure an h of 2,000 Btu. per (hr.) (sq. ft.) (deg. F.) was the maximum obtained under conditions where the Nusselt theory value was 13,000.

A theoretical analysis of the condensation of metal vapors by Seban,[34] based on the von Karman velocity distribution of Fig. 1, shows that the development of turbulence in the falling film should decrease rather than increase the heat-transfer coefficient over that predicted by the Nusselt relation for a streamline film. This is, as before, because the eddy conductivity of the turbulent portion of the film does not increase with thermal conductivity, and h does not increase as rapidly as k.

Early results on the boiling of liquid metals[6, 23] indicate nucleate boiling and high coefficients under wetting conditions, but only film boiling and low coefficients with non-wetting. These results agree with general experience on mercury boilers.

HEAT TRANSFER IN BOILING

Previous data on the nucleate boiling of a stationary pool of liquid have been analyzed by Rohsenow,[32] who developed an equation which correlates data for a given liquid and surface reasonably well at all pressures. However, it contains an uncorrelated proportionality factor, described as dependent on the nature of the liquid and surface, which varies over a range of 5.5 to 1. In addition, the equation is not dimensionless, an annoyance in previous studies of boiling.

Bromley[4] has shown that film boiling at a horizontal pipe in a stationary pool of liquid is analogous to condensation on a horizontal pipe with the phases and direction of flow and heat transfer reversed and an added term for radiation. He obtained good correlation of available film boiling data with the Nusselt equation for condensation. The physical properties employed are thus those of the vapor phase except for the one power of density in the convection driving force which remains unchanged as the density difference between the phases. Upward forced convection of the liquid at low rates follows the same relation,[5] while at higher rates the vapor film becomes thinner, as expected, and a modified correlation was found.

A third form of boiling, reported first by McAdams only in 1949, has received most attention on account of the high heat fluxes possible without overheating the surface, particularly with forced circulation. This is "local" boiling, in which the liquid surrounding the boiling surface is below the boiling point.[26] Substantially all the heat is transferred by hemispherical bubbles, which continually grow and collapse very rapidly on the heated surface, producing extreme kinetic effects in the liquid phase.[18] The coefficients are very high at high q/A and are best correlated when computed from the difference between the wall and saturation temperatures. The pressure of dissolved gas aids nucleation and, therefore, local boiling.

ELECTRICAL ANALOGUES

Electrical curcits to simulate complicated heat-transfer problems are receiving increasingly wide and intense application. One laboratory, for instance, is known to have employed thousands of variable resistors at one time in several steady-state analyses.

The circuits so far employed simulate thermal capacity with electrical capacity, thermal resistance with electrical resistance, heat with current, and temperature with voltage. The electrical resistance is frequently a one, two, or three-dimensional network made up of constant or variable resistors. Wire-wound resistors are more permanent, but machine-cut carbon resistors are cheaper and more accurate, and have a temperature coefficient of only about 1 percent per 40 deg. C., usually adequately low.

In other cases a two or three-dimensional homogeneous resistance is employed, having the same proportions as the problem. The latter technique has been difficult to apply because of the lack of any commercial sheet material of reasonably high electrical resistance which is also uniform in all directions and avoids contact resistance. This shortcoming now seems solved by the availability from General

Electric Co. of wide conducting paper in long rolls, stated to vary no more than ± 8 percent in any direction. Silver-bearing paint is applied for isothermal edges and areas.

The need for careful design of an electrical analogue circuit to give reliable results in an unsteady-state problem was recently pointed out by Klein.[20] For instance, the potential at the first section in a one-dimensional network of any number of sections will first be much too high, and then drop to 35 percent too low, before leveling off at the correct value.

Besides applications to stationary thermal problems, it is possible to represent a fluid stream by electrical resistance proportional to its resistance to change in temperature, namely, its wc product. This yields directly the relative temperature distribution for any given heat-transfer coefficient variation.[illegible] Another technique is to represent wc by electrical capacity and heat-exchanger length by electrical time. A three-fluid heat exchanger has been so handled.[illegible]

NUMERICAL METHODS

The use of "relaxation" methods[illegible] for solving steady and unsteady-state problems by hand has greatly expanded. Current practice for a steady-state solution is to "relax" successively those points where the unbalance is greatest, rather than systematically to cover the whole grid time and time again.

Alternatively, it is possible with electronic digital computers to feed in all the data of a steady-state problem and solve the equations (one for each unknown temperature in the grid) simultaneously, obtaining the solution directly without any trial-and-error or "relaxation" procedure. *N* simultaneous equations require on the order of N^3 arithmetical operations for their solution, from which the operating time required by the machine can be estimated. When a uniform grid is used and extrapolated temperatures or temperature gradients are desired, Wu's tables[38] for numerical differentiation are convenient.

Electronic computers find particular application in the numerical integration of complex differential equations, such as in the prediction of skin temperatures for a rocket. In general, the differential equations are replaced by difference equations, which are solved by one of several methods of successive approximation.[illegible] Since the first major electronic digital computer was completed in 1946 at least 25 types have been or are being built.

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Trends in Heat Exchangers

Greater use is being made of non-tubular units, extended surface and improved shell-and-tube designs.

New types of heat exchangers have been developed and older ones improved in recent years in order to solve new processing problems and find more economical ways of solving old ones. Process pressures and temperatures are higher; process fluids are more dangerous and more corrosive; various forms of energy cost more than they did ten years ago; cost of skilled labor for maintenance has sky-rocketed. Water is getting scarce, too, in certain parts of the country.

Some of these problems have required the revision of old concepts in equipment design and the development of entirely new devices. Especially is this true in the atomic energy program, where heat transfer with liquid metals and radioactive fluids has

become common. As methods to convert atomic energy into industrial power are developed and as jet planes and rockets fly ever faster into the stratosphere and beyond, the problems in heat transfer become great indeed.

To solve these problems equipment designers are finding ways to make cheaper, more effective heat-transfer surface. Economies have come through mass production and standardization of designs, especially small shell-and-tube units; through refinements in the design of conventional exchangers; and through the use of completely new types of exchangers.

Air-cooled units, evaporative coolers and extended-surface exchangers of a variety of designs have come into wide use. Air-cooled exchangers have replaced water-cooled units in many parts of the country. There has been a noticeable trend away from straight-tube exchangers toward spiral exchangers, plate exchangers and other non-tubular designs. Particularly clear is the trend toward plate units, which have high capacity at low cost. Their limiting factor seems to be pressure, for plate exchangers are not yet good for much above 250 psi.

Installation costs are being lowered by the trend to more compact designs, up to 450 sq. ft. per cu. ft. Probably this trend will continue as still more ingenious ways of extending the effective surface are found.

Maintenance and power costs are being reduced by making exchangers easier to clean, or self-cleaning, and by minimizing the pressure drop through them. Materials of construction like copper-based and aluminum-based alloys, tantalum, glass and graphite are going into more and more heat exchangers, sometimes of conventional design, sometimes—because of the properties of the particular material—of designs that are completely new.

Low-cost heat-transfer equipment has led to the increased recovery of what was previously considered waste heat, especially in the petroleum and textile industries. Close temperature approaches, down to as little as 5 deg. F., have become economical in many cases.

These developments illustrate the directions in which the design of heat-transfer equipment has been going and is likely to go in the future. Yet it should not be forgotten that despite the new designs and techniques, old methods continue to be satisfactory in many places. Shell-and-tube exchangers, for example, are still made in vast numbers and probably will continue to be made for many years to come, especially as designs become standardized and costs are reduced.

SHELL-AND-TUBE IMPROVEMENTS

Extensive experience with shell-and-tube exchangers has permitted manufacturers to design units with much more confidence than in earlier days and to standardize designs without loss of effectiveness. Several lines of small inexpensive mass-produced exchangers have been put on the market by companies such as Kewanee-Ross, Bell and Gossett, and Patterson-Kelley.

Kewanee-Ross has developed methods of roller-expanding very small tubes, ¼ and ⅜ in. in diameter, and supplies standard shell-and-tube units containing as little as 1.2 sq. ft. Pfaudler now offers a line of standard exchangers of stainless steel and other alloys. The Brown Fintube sectional exchanger is an extended-surface exchanger with standardized parts, designed so that banks of them can be easily dismantled, rearranged or replaced.

Several companies make shell-and-tube exchangers using hairpin tubes secured to a single tube-sheet. These units virtually eliminate leakage between the shell and tube fluids and, since the tubes float at one end, avoid the problem of differential expansion.

The tube bundle is easily removed and may be used without a shell as a tank heater inserted through the tank wall. Although the outside surface is easily cleaned, it is hard to clean the inside of the tubes mechanically. Also, the exchangers contain somewhat less heat-transfer area per unit volume than straight-tube units.

They are widely used as instantaneous water and oil heaters, often to heat cold viscous oils so that they may be pumped easily. To start cold oil flowing, Davis makes a suction-bell heater with a single circular tube heated with steam or hot water; the heater is connected with flexible lines to the pump suction and inserted through a manhole into the tank.

EXCHANGERS FOR EASY CLEANING

Many advances in heat exchangers have been in the direction of making cleaning easier or automatic. For food processing, straight-tube sanitary exchangers have been developed; the units made by Arnold feature large tubes (1½ to 2 in. in diameter) and hinged-gasketed endplates secured by a handwheel. In the Graham Monobolt exchanger the tube bundle is easily pushed out of the shell, using a sturdy integral bolt as a jack.

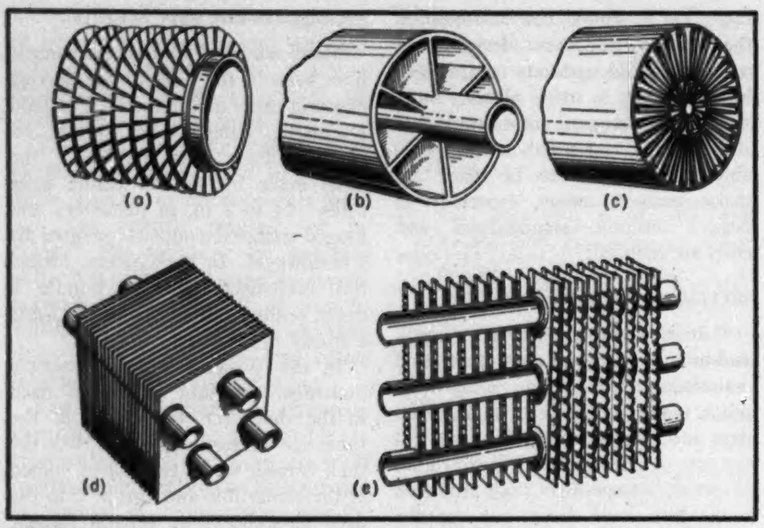
In the Western Supply telescopic exchanger the tube bundle is fixed to the shell, yet the outside of the tubes can be easily cleaned. Here the shell is made up of two halves, joined at the center line and also held to the fixed tube-sheets by vertical flanges. Half the shell is split horizontally; surrounding the split half is a flanged sleeve carrying a packed gland to keep the shell fluid where it belongs.

To clean the unit the gland ring is loosened, the sleeve slid away from the split half of the shell, and the split half removed. This exposes about half the tube bundle. After this part is cleaned, the other half of the shell is telescoped over the cleaned part of the tubes, exposing almost all the rest of the bundle for cleaning.

One method of keeping scale from building up on exchanger tubes is to make the tubes bend and straighten as they change in temperature. Griscom-Russell Bentube units contain several banks of parallel tubes, slightly bowed when cold and held rigidly between fixed tube-sheets. As the tubes are warmed they bend and crack away surface scale; on cooling the restraightening removes additional deposits. Such exchangers are especially useful in scale-forming evaporators.

Other devices use mechanical methods of scraping the surface clean. Manual or fully automatic cleaning is possible in Davis' white-water heater. This straight-tube unit, developed for the paper industry, contains bayonet tubes fed with steam from small internal pipes. The tubes are fixed at one end only. The outside of the tubes is cleaned by segmented baffles mounted on an independent assembly of a yoke and tie rods, which is driven back and forth longitudinally at a controlled rate by a motor or a hydraulic ram.

In the Vogt scraped-surface ex-



EXTENDED surfaces—(a) Segmented (Kentile); (b) concentric radial (Modine); (c) internal (Heat-X-Changer); (d) transverse (Trane); (e) Ripple-Fin (McQuay).

changer the inside of the tube is cleaned mechanically. The tube, 6 in. in diameter, contains a rotating flight of spring-mounted scraper blades. The outside of the tube may be heated or cooled by steam, water or refrigerant; the solution to be processed flows through the tube. Standard units consist of either a single jacketed tube, 34 to 44 ft. long, or seven such tubes in a single shell to provide about 440 sq. ft. of heat-transfer surface. These machines find use in dewaxing lubricating oils, crystallizing Glauber's salt and caustic soda, winterizing vegetable oils and similar applications.

In a device very different from the usual tubular exchanger the surface is kept clean by wiping it against the material being processed. The Holo-Flite, made by Western Precipitation, is a screw conveyor designed for heating or cooling pastes, sludges and solids. Two, four or six intermeshing helical screws rotate at 1 to 12 rpm. in a single trough. A heat-transfer agent flows through the hollow flights and shafts of the screws; the constant turning and folding of the material by the helix keeps the heat-transfer surface wiped clean.

SPECIAL TUBULAR EXCHANGERS

Operating pressures have risen steadily, so that pressures of 3,000 psi. are almost as common today as 1,000 psi. was 20 years ago. To handle high pressures Griscom-Russell has developed the Type L breech-block head for shell-and-tube exchangers. The inner circumference of the head and the periphery of the cover have matching projections. When the cover is inserted and turned a few inches, these projections engage each other and lock the cover in place. The hydraulic load is thus carried by the projections, not by bolts, so that only a light pressure-sealing ring and gasket are needed.

One way of guaranteeing that there will be no leakage or contamination of liquid streams in an exchanger is to use a block of cast aluminum in which are embedded separate coils to carry the two fluids. Units like this are supplied by the Heat-X-Changer Co., with liquid-carrying tubes of steel or stainless steel. They are most used for cooling water in bakeries and bottling plants.

Another Heat-X-Changer design involves a single straight tube, ½ to 2½ in. in diameter, surrounded by a sleeve of cast aluminum. The tube contains longitudinal internal fins. In the sleeve is a coil containing water or other coolant. Although these exchangers were designed for use in refrigeration systems, they should be valuable in other applications where any mixing of the process fluids cannot be tolerated.

EXTENDED SURFACE EXCHANGERS

Use of extended surface is indicated where one film coefficient, because the fluid on that side is a gas or viscous liquid, is much lower than the coefficient on the other side. In some recent designs fins are provided on both sides to increase the rate of heat transfer through both films.

There are two main types of fins—transverse, often made by attaching a spiral strip to the tube; and longitudinal or radial. Continuous spiral fins have been available for 30 years and are still widely used, especially in air heaters. A welcome development in this field is the Aerofin non-freeze air heater, designed so that steam condensate cannot freeze in the exchanger. This is done by using a bayonet arrangement, with steam inlet and condensate outlet at the same end of the coil. Condensate flowing to the outlet header is kept warm by contact with the inner tube carrying the incoming steam.

Other trends are toward interrupted fins or fins of special shapes, with tubes of unusual cross-section sometimes used. The McQuay Ripple-Fin exchanger contains staggered tubes and fins with rippled edges that increase the turbulence of the air. Discontinuous or segmented fins have been shown to give high rates of heat transfer; they are used in exchangers sold by the Tilco-Fin Div. of Kentile.

Transverse fins extending across several tubes in a bank are also available. Tubes with unusual cross-sections are featured by Modine. Flat seamless tubes with corrugated outside fins: flattened tubes with longitudinal internal fins and interrupted external fins; streamlined tubes with flat fins; these are typical designs.

Longitudinal fins are most used in exchangers handling viscous liquids or where a very low pressure drop in a gas stream is desired. A typical design is the Griscom-Russell Twin G-Fin section, a compact standardized exchanger. Concentric radial fins, fusion bonded outside a small tube and inside a larger one, are a development of Modine. Sometimes internal longitudinal fins are used, or both internal and external fins on the same tube. Such tubing is supplied by Modine and by Heat-X-Changer.

The Brown Thermo-Flo heater is an adaptation of longitudinally finned tubing for heating viscous liquids in tanks. It is a compact unit, comprised of several parallel finned tubes, 4 ft. long, connected to a manifold and mounted vertically near the tank bottom. In large tanks several such heaters are used. They give much more rapid and effective heating than do

spiral coils of bare tubing and set up vigorous flow currents even in heavy oils.

AIR-COOLED EXCHANGERS

Water, most used of all coolants, is becoming scarce in many western states, and elsewhere, too. It also has some disadvantages; it corrodes and scales heat-transfer surfaces; it freezes; it has to be disposed of after use. Air, on the other hand, is always available and does not corrode or freeze. Its only real drawback is that it gives low heat-transfer coefficients.

As water has become more valuable, air-cooled exchangers have found application for nearly all kinds of condensing and cooling services. Typically, they consist of banks of finned tubes carrying the hot fluid, across which air is blown at high velocities by large fans. Coolers of this kind are made by Marley, Griscom-Russell and several other manufacturers. They are bulky, but not unreasonably so. They are particularly applicable where the hot fluid is really hot, with a minimum temperature difference between the air and the hot fluid of about 50 deg. F.

Another use of air in process cooling is in evaporative cooling. It has long been known that in cascade or trombone coolers some of the heat was removed through evaporation of water into the atmosphere, but only in the past few years has this effect been studied quantitatively. National Radiator Co. has found that evaporative cooling is highly useful with its standard cast-iron condensing and cooling sections, wherever water is expensive or very hard. In such a situation the water, treated if necessary, is recirculated, with only enough added to make up for the relatively small amount lost through evaporation and splashing.

SPIRAL EXCHANGERS

Most of the exchangers described so far are conventional in appearance, if not in internal design. Spiral exchangers are not. They consist of short cylindrical shells with flat heads, carrying inlets and outlets leading to internal spiral passages. These passages may be made with spiral plates or with spiral banks of tubes.

Tubes are used in the Graham Heliflow exchanger. Very small units contain a single spiral tube, held between the head and the flat floor of the shell; larger units employ several spirals set tightly one above the other. One fluid flows inside the tubes, the other in the narrow channel between the tube banks. Flow is truly countercurrent, and the chance of one fluid leaking into the other is almost nil.

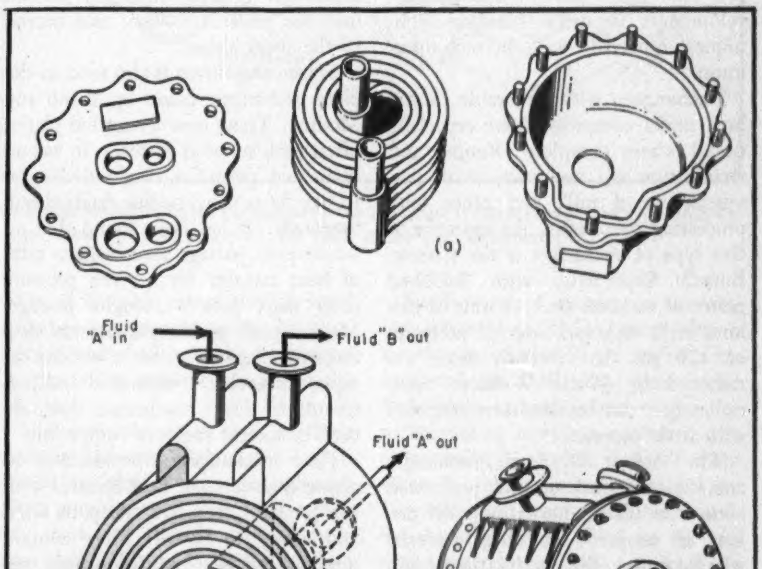
Heat-transfer coefficients are high, with a somewhat larger pressure drop inside the spiral tubes than if they were straight; on the shell side the pressure drop is low because no baffles are needed. The spiral design also allows for differential expansion between the tubes and the shell. Standard exchangers will stand pressures up to 1,500 psi. on the tube side and 600 psi. on the shell side. They are made in sizes ranging from 0.5 to 108 sq. ft.

The Rosenblad exchanger (American Heat Reclaiming Corp.) contains spiral passages formed by partitions of metal plates. In these exchangers one fluid enters through one head and leaves through the other; the second fluid enters and leaves through the wall of the casing. The edges of alternate channels may be welded shut at the ends to eliminate leakage. Both spiral passages are of rectangular cross-section and flat-walled, leading to very low pressure drops. Heat-transfer coefficients are high.

Various designs are available for liquid-liquid coolers, vertical surface condensers and liquid heaters; a new design features a hinged cover and wide passages for quick easy cleaning. Sizes range up to 2,200 sq. ft. per unit.

PLATE EXCHANGERS

Under pressure to find cheaper ways of supplying heat-transfer surface, many designers have turned away from tubular exchangers. Sheets or plates of metal, corrugated or embossed, are cheaper per sq. ft. of surface than are tubes. The trick was to find ways of making plates into exchangers that would carry fluids under pressure without leakage. One way is the spiral plate exchanger just described; other ways are to assemble stacks of plates with gaskets between them and hold the assembly in an external form; or to bond the plates permanently together at the lines of contact to form



SPIRAL exchangers—(a) Tubular (Graham); (b) plate (American Heat Reclaiming).

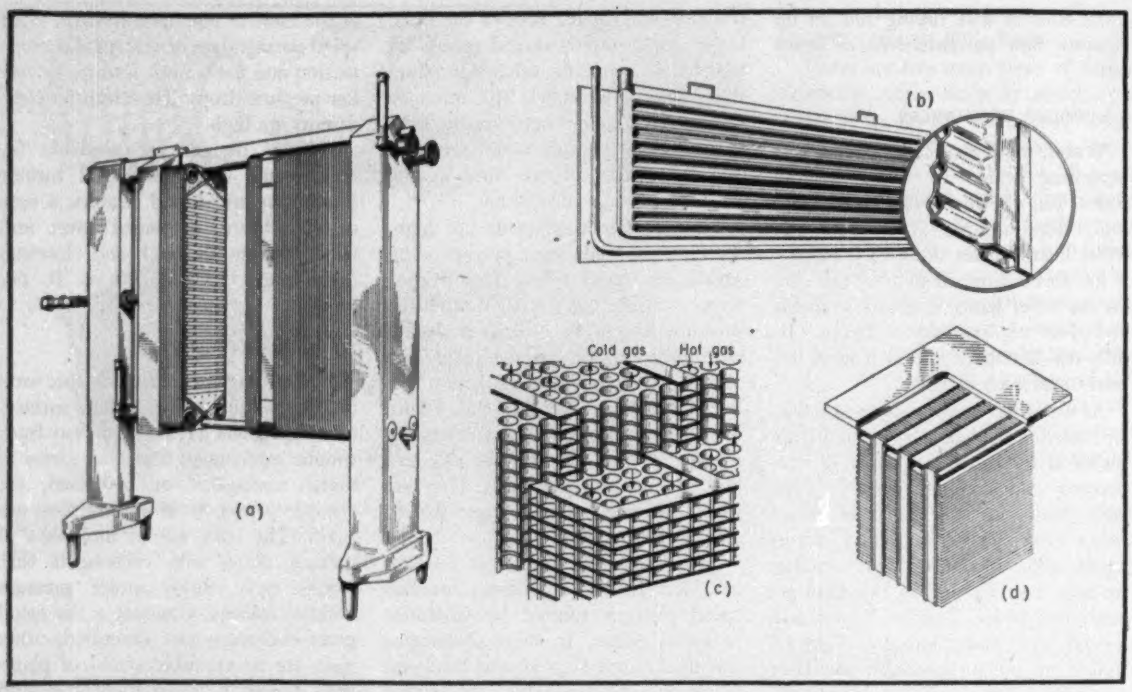


PLATE exchangers—(a) Separable plates (Walker-Wallace); (b) Platecoil immersion heater (Kold-Hold); (c) gasketed perforated aluminum (Arthur D. Little); (d) brazed corrugated aluminum (Trane).

leakproof channels. This last method has been made possible through developments in metal bonding techniques, especially with brazed aluminum.

Exchangers with separable plates held under compression are especially useful where complete cleaning and sterilization are necessary, as in pasteurization of milk and other food processing operations. An example of this type of exchanger is the Cherry-Burrell Superplate, with knobbed plates of stainless steel. A unit of this kind built to stand internal pressures of 120 psi. has recently been announced by Walker-Wallace. Such exchangers can be rebuilt or extended with little expense.

The Arthur D. Little exchanger consists of a stack of thin perforated aluminum plates alternating with gaskets of neoprene or other material which group the perforations into longitudinal channels. This exchanger was designed for cooling large quantities of gas, especially for tonnage oxygen plants. Rates of heat transfer are high because the gas passes through what is in effect a series of orifices; repeated compression and expansion insure turbulence even when the flow rate is low. Recent designs of this exchanger incorporate brazed aluminum gaskets, or ridges pressed into the perforated sheet and brazed to the sheet above.

Brazed aluminum is also used in the plate exchangers made by Trane and Modine. Trane uses corrugated plates, often with serrated patterns, in assemblies that permit a single exchanger to handle as many as five fluids simultaneously. It has been found that an interrupted passage gives higher rates of heat transfer for a given pressure drop than does a straight passage. Modine plate exchangers contain strip fins or corrugated plates of various designs; channel fins, embossed and perforated to direct condensate flow, are used in solvent recovery equipment.

Plate exchangers, in addition to giving high rates of heat transfer with low pressure drop, are cheap to build and cheap to install. They contain much more heat-transfer surface per unit volume than do shell-and-tube exchangers. A tubular exchanger typically contains 25 to 50 sq. ft. per cu. ft.; plate exchangers provide 80 to as much as 450 sq. ft. per cu. ft. Units have been made to operate at minus 300 and plus 500 deg. F., and under working pressures up to 300 psi. It is claimed that these exchangers make economical temperature approaches between process fluids of 5 to 10 deg. F., where in earlier days the rule was 20 to 50 deg.

A somewhat different plate exchanger is the Platecoil, made by Kold-Hold Mfg. Co. This is usually in the form of an immersion heater, designed to replace coils of pipe in rectangular electroplating tanks and pickling baths. Platecoils consist of sheets of 16-gage metal, seam and spot-welded together and embossed to form transverse internal channels which carry the heat-transfer medium. The channels lead to standard pipe nipples.

The entire exchanger is a single light unit, weighing half as much and taking half the space of a bank of pipes of equal surface area. It is mounted in a tank on two strap hangers that fit over the top of the tank wall, so that disassembly and removal for inspection and cleaning are easy. Designs are supplied with widths from 12 to 22 in. and heat-transfer areas from 1 to 42 sq. ft. The all-welded construction means no threaded joints in the tank, also that initial costs are low. Platecoils are ordinarily supplied in mild steel, Type 316 stainless steel and Monel.

CORROSION-RESISTANT EXCHANGERS

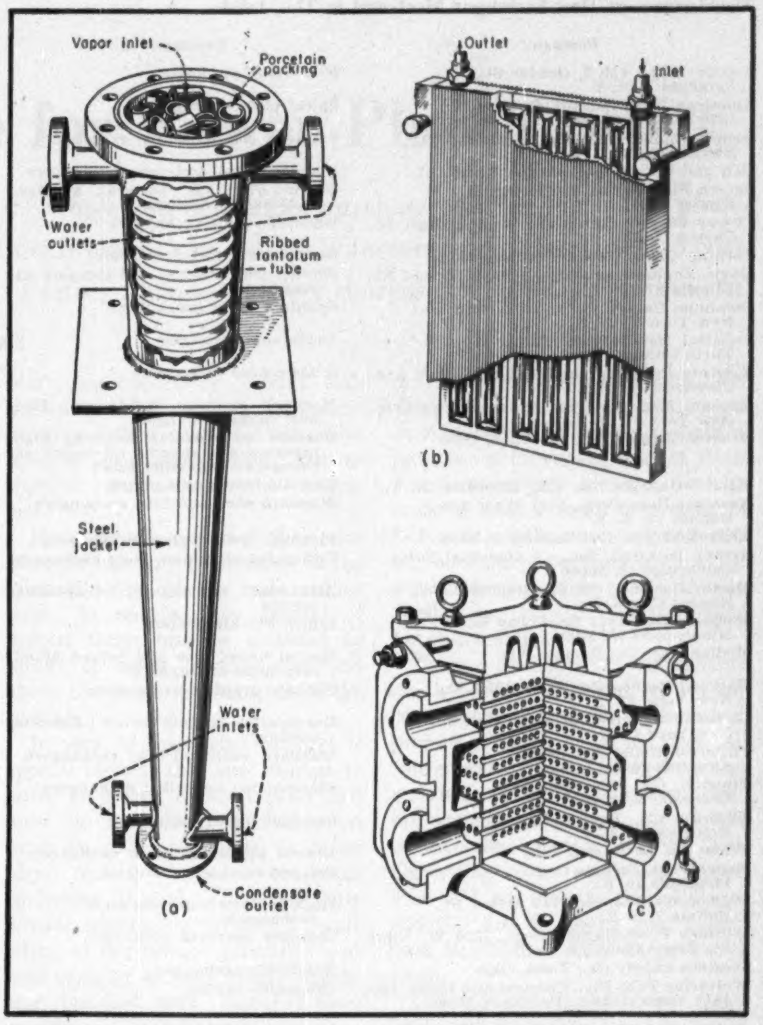
Bimetallic Tubes—In many applications of tubular exchangers the fluid on one side of the tubes has very different corrosion characteristics from those of the fluid on the other side. An example is cooling wet ammonia with salt water—the ammonia attacks copper-bearing alloys, but not steel; the brine corrodes steel, but not bronze. To meet such conditions, companies like Wolverine now furnish bimetallic tubes with an interior surface of one metal and a skin of another. Bimetallic finned tubing is also made by Wolverine, Griscom-Russell and others.

Tantalum Exchangers—Some of the very nasty corrosive fluids that chemical manufacturers work with today are best handled in equipment made of tantalum. Usually, but not always, its first cost is greater than that of stainless steel, so that its applications are ordinarily limited to handling things like HCl, HBr and nitric acid; and to pharmaceutical and fine chemical operations where contamination by corrosion products cannot be tolerated.

Fansteel tantalum bayonet immersion heaters may be inserted through a nozzle into a glass-lined or ceramic vessel; single tubes range up to 2 in. in diameter and 7 ft. in length. Steam is admitted through a slotted internal feeder tube. Tantalum shell-and-tube exchangers for handling liquids like hot chlorine solutions are made in sizes to 188 sq. ft or more. Cooling coils for agitated glass-lined vessels, double-pipe exchangers, and tantalum-sheathed electric immersion heaters are also available.

Tantalum condensers consist of a large tapered tube of thin ribbed tantalum, set vertically with the small end down and packed with porcelain rings. Cooling water or refrigerant flow through a steel jacket. Vapor enters the large top end, and condensate leaves from the bottom. The decreasing diameter keeps the vapor velocity high, so that heat-transfer rates as high as 120,000 Btu. per hr. per sq. ft. are not unusual.

Graphite Exchangers — Impervious graphite is remarkably inert to most corrosive agents and has other valuable properties, such as high thermal conductivity, low coefficient of thermal expansion, and strength at high temperatures. Because of these properties it is used extensively in heat-exchange equipment; plate, bayonet, cascade and shell-and-tube exchangers of impervious graphite are all on the market.



CORROSION-RESISTANT exchangers—(a) Tantalum condenser (Fansteel); (b) graphite plate heater (National Carbon); (c) cubic exchanger (Delanium).

Shell-and-tube units, such as those made by National Carbon, can be furnished in almost any size, though when graphite tube sheets are necessary it is not feasible to put more than about 600 sq. ft. of surface in a single unit. Because of graphite's low coefficient of thermal expansion relative to that of the steel shell, floating heads must be used—by a packed joint around a discharge nozzle, a double-packed joint on the periphery of the floating tube sheet, or a flexible diaphragm between the shell and the floating head.

Small standard exchangers containing seven 1½-in. O.D. tubes, with a working pressure of 50 psi. on both the tube and the shell sides, have found their place as heaters and coolers for nickel-plating solutions, coolers in the chlorination of alcohol, in DDT manufacture, and similar applications. Graphite plate heaters withstand internal steam pressures of 25 to 30 psi.; they are particularly well suited for use in steel-pickling baths.

Cubic Exchangers—A new material of construction, Delanium, has been announced by the Delanium Carbon Corp. Developed in England, Delanium is a very dense form of carbon made by heat-shrinking specially selected coals, followed by graphitizing. It has high compression strength,

Manufacturers of Heat Exchangers Mentioned in This Article

Company	Development
Aerofin Corp., 410 S. Geddes St., Syracuse 1, N. Y.	Non-freeze air heaters
American Heat Reclaiming Corp., 1270 Sixth Ave., New York 20, N. Y.	Spiral plate exchangers
Arnold Equipment Corp., 3080 Main St., Buffalo 14, N. Y.	Sanitary shell-and-tube exchangers
Bell and Gossett Co., Morton Grove, Ill.	Standard shell-and-tube exchangers
Brown Fintube Co., 150 Huron St., Elyria, Ohio	Thermo-Flo tank heaters; standard sectional exchangers
Cherry-Burrell Corp., 427 W. Randolph St., Chicago 6, Ill.	Separable plate exchangers
Corning Glass Works, Corning, N. Y.	Glass coolers and condensers
Davis Engineering Corp., 1064 E. Grand St., Elizabeth 4, N. J.	Suction bell heaters; self-cleaning exchangers
Delanium Carbon Corp., 18 E. 48th St., New York 17, N. Y.	Graphite cubic exchangers
Fansteel Metallurgical Corp., North Chicago, Ill.	Tantalum exchangers
Glascote Products, Inc., 20900 St. Clair Ave., Cleveland 17, Ohio	Glass-coated exchangers
Graham Mfg. Co., Inc., 415 Lexington Ave., New York 17, N. Y.	Monobolt sanitary exchangers; Heliflow spiral exchangers
Griscom-Russell Co., Massillon, Ohio	Bentube self-cleaning heaters; high-pressure exchangers; air-cooled exchangers; bimetallic tubes
Heat-X-Changer Co., Inc., Brewster, N. Y.	Cast aluminum exchangers
Kewanee-Ross Corp., 1407 West Ave., Buffalo 13, N. Y.	Standard shell-and-tube exchangers
Kold-Hold Mfg. Co., Lansing 4, Mich.	Platecoil welded plate exchangers
Arthur D. Little, Inc., 30 Memorial Drive, Cambridge 42, Mass.	Perforated aluminum plate exchangers
Marley Co., Inc., 222 W. Gregory Blvd., Kansas City 5, Mo.	Air-cooled exchangers; evaporative coolers
McQuay, Inc., 1622 Broadway St., N. E., Minneapolis 13, Minn.	Ripple-Fin air heaters
Modine Mfg. Co., Racine, Wis.	Special finned-tube and brazed aluminum plate exchangers
National Carbon Co., 30 E. 42nd St., New York 17, N. Y.	Karbate graphite exchangers
National Radiator Co., 60 E. 42nd St., New York 17, N. Y.	Evaporative cascade coolers; Kolmetal coatings
Patterson-Kelley Co., Inc., East Stroudsburg, Pa.	Standard shell-and-tube exchangers
Pfaudler, Co., 1000 West Ave., Rochester 3, N. Y.	Glass-coated and alloy exchangers
Tilco-Fin Div., Kentile, Inc., Brooklyn 15, N. Y.	Serrated finned tubing
Trane Co., La Crosse, Wis.	Brazed aluminum plate exchangers
Henry Vogt Machine Co., Louisville 10, Ky.	Scraped-surface exchangers
Walker-Wallace, Inc., 137 Arthur St., Buffalo 7, N. Y.	High-pressure separable plate exchangers
Western Precipitation Corp., 1016 W. Ninth St., Los Angeles 15, Calif.	Holoflite conveyor exchanger
Western Supply Co., Tulsa, Okla.	Telescopic exchanger
Wolverine Tube Div., Calumet and Hecla, Inc., 1411 Central Ave., Detroit 9, Mich.	Bimetallic tubing

but like other graphite it is brittle and weak in tension.

To make the best use of its good properties exchangers made from it are of a novel design. They consist of a cube of Delanium 9 to 15 in. on a side, held in a metal casing. Rows of holes are drilled in one direction through the cubical block; between these rows, and at right angles, are other similar holes. The exchanger is two-pass with both streams. Heating or cooling fluid enters through one head, passes through one set of holes, returns, and is discharged through metal pipes. The corrosive fluid follows a similar path through the other set of holes, except that here the cover plates and fluid lines are also of Delanium.

Standard sizes contain 50 and 105 sq. ft. of surface. Steam pressures up to 50 psi. can be used.

Glass and Glass-Lined Exchangers—In very recent years glass has become an accepted material of construction for many kinds of process equipment, including heat exchangers. A length of 4-in. glass pipe is used in an iodination process as an air-cooled condenser in which iodine crystallizes. Cascade coolers of standardized design, made by Corning Glass Works, are used for cooling corrosive solutions with a minimum of cooling water. The tubes are 10 ft. long with walls $\frac{3}{16}$ in. thick; they are used in double banks containing up to 24 tubes, 12 to a bank.

Despite the relatively low thermal conductivity of glass, the over-all coefficients of heat transfer are not small. In tests of heat exchange between hot and cold water the coefficients ranged from 50 to 75 Btu. per (hr.) (sq. ft.) (deg. F.).

Double-pipe exchangers—glass pipe surrounded by steel jackets—are also supplied by Corning. Double-pipe exchangers utilizing glass-lined pipe are made by Pfaudler and by Glascote. Where glass pipe can safely withstand internal pressures of 50 psi. at most, glass-lined pipe can stand several hundred psi.

Cascade coolers of glass-lined pipe are also available, which give somewhat higher heat-transfer rates than do similar glass coolers; but they do not permit the operator to see what is going on inside the pipe. Sometimes this is a great advantage in favor of glass.

Glass-lined condensers are often of the tube-and-thimble type, containing two glass-coated water-cooled surfaces. They range in area from 9 to 160 sq. ft.

Plastics—In the constant battle against corrosion these materials—tantalum, graphite, glass—have proved to be of great value. Their usefulness, however, has been extended, even made possible, through improvements in gasketing and packing materials. The "noble" plastics like polyethylene, Kel-F, and above all, Teflon, have made it feasible to build processing equipment that is completely corrosion-resistant throughout.

Instead of using special materials, another approach has been to coat the heat-transfer surface with a resistant paint, as in the National Radiator Kolmetal process. This involves a vinyl plastic plus an aluminum paint, which reduces salt-water corrosion and prevents the growth of slime and algae on water-cooled surfaces.

ACKNOWLEDGMENT

Thanks are due the manufacturers listed in the above table for their cooperation and assistance in the preparation of this article.

NEXT MONTH . . .

Plastics as materials of construction for chemical process equipment will be the subject of next month's feature report.

Critical properties of the various common types will be compared as an aid to selection. Industrial experience with the various types will also be covered as a further guide to selection.

Fast Estimate for Power Plant Costs

Once you determine purchase cost for the major pieces of plant equipment you can apply factors to give final erected cost. Factors include indirect charges for auxiliary equipment.

T. A. FERNSIDE and F. C. CHENEY

An engineer is frequently called upon during preliminary discussions with management to provide a quick, "blue sky" or "off the cuff" estimate of the total cost of a proposed power plant. This is comparatively simple in the case of a utility station, for which costs may be predicted on a "dollars per kilowatt" basis. The industrial power plant, however, obviously can not be measured by the utility yardstick.

In this article a set of simple factors is presented which can be applied to readily obtainable purchase costs of major equipment items to give rapid and reasonably accurate determination of the major portion of the total project costs for an industrial power plant. These factors take into account variables such as process steam requirements, special turbine steam extraction or back pressure conditions and in addition the current level of market prices.

Utility power plant installations, while not standardized in any absolute sense, appear highly standardized when compared with the infinite variety of industrial power installations now functioning in the United States. In most utility power installations, with any given steam conditions, boilers are definitely sized in proportion to the number of kilowatts being generated. Also the number of feeders leaving the generating station proper is usually small.

By comparison, industrial power stations have installed boiler capacity which usually bears no relation whatsoever to the number of kilowatts being produced. Only rarely do such plants use condensing turbines with uncontrolled extraction for feed water heating. Rather controlled extraction turbines are employed either with or without condensers on the exhaust end.

If condensers are used their size bears no necessary relationship to the kilowatt rating of the turbine they serve. In addition, any amount of process steam may be provided by means of boiler capacity over and above the steam requirements of the turbines.

In view of these circumstances it appears obvious that any attempt to arrive at industrial power plant cost must be subdivided. Consideration must be given separately to boiler plant, turbine plant and condenser equipment, if used. There is a fairly definite relationship between kilowatt rating of the turbine generators and total capacity of main power switchgear installed with them. Consequently such switchgear may be considered as a part of the turbine plant.

BASIS FOR COST FACTORS

It has been the writers' experience that the better known manufacturers are able to provide, on short notice, quite accurate estimates of current selling prices of boilers, industrial type turbine generators, main power switchgear and condensers. The general description and rating of each of these major equipment items would be known in the light of steam and power requirements for a given project.

Furthermore, it seems reasonable that the total cost of all elements of power plant construction, including field labor, would bear a more or less constant relationship to the market prices of major equipment items listed above. This relationship can be derived from known costs of completed projects. If for varying types of plants it remains roughly constant, we have ready at hand a factor or a series of factors to provide a means for estimating industrial power plant costs. These would be comparable to the familiar "dollars per kilowatt" measure, used for utility stations.

Factors developed to substantiate our hypothesis are based on a study of completion costs for 10 industrial projects of varying types and sizes. All conventional types of firing were represented, including pulverized coal, oil, spreader stoker, gas and certain combinations of more than one fuel. Generating steam conditions ranged from 275 psi. saturated to 1,300 psi. and 900 deg. F. Boiler sizes ranged from 80,000 to 450,000 lb. per hr. of steam.

One project involved one small boiler with no turbine generator while another included three large boilers and two turbine generators. All turbines were special machines, with sizes ranging from 2,000 to 40,000 kw. While most were of the controlled extraction condensing type, a few were straight back pressure. Project completion dates with one exception were in the postwar period from 1945 to 1952.

Each factor is a multiplier for estimated selling price to give an approximate erected cost of that portion of the total project directly related to the major equipment item concerned. Three factors are presented covering, respectively, boiler plant, turbine and switchgear, and condensing system. Each factor may be used alone or in any combination. Application to appropriate manufacturers' estimated prices will produce a total installed cost, including all indirect charges,

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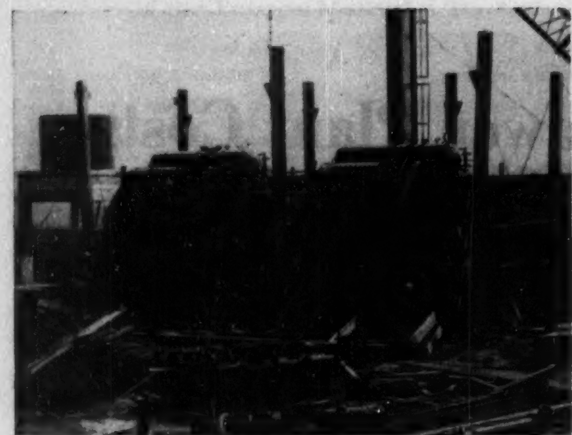
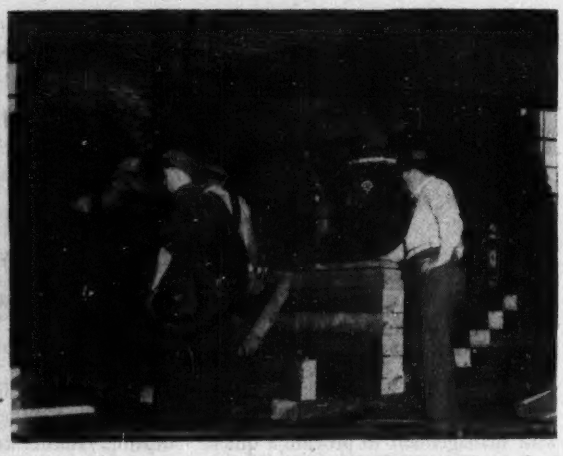
From a paper presented before the Power and Management Divisions, ASME, annual meeting at New York November 30 to December 5, 1952.





ERECTION OPERATIONS for boilers, turbine, generator and auxiliaries have costs which are proportional to initial purchase

for all boiler, turbine, condenser and electrical equipment items.

FACTORS ARE LIMITED

It should be recognized that individual cases vary widely. Useful factors can not be worked out to cover certain cost items. One or more of these will nearly always be found on industrial installations. Such items include:

1. Amount of excavation, piling and special foundation conditions.
2. Amount of yard piping. Industrial projects often include yard piping systems extending far beyond the comparable normal "battery limits" of a utility power installation.
3. Amount of yard electrical feeder runs. This is just as unpredictable as yard piping systems.
4. Large or special water treating plants, which must sometimes supply more than normal boiler makeup requirements.
5. Buildings, which vary from complete enclosures for turbines and boilers to completely open outdoor stations.
6. Other yard installations such as circulating water intakes, coal and ash handling systems and oil storage facilities.
7. Air compressors to supply process requirements over and above power plant needs, and refrigeration equipment for air conditioning.

Since these items contribute to overall cost the total station cost will be the sum of approximate erected cost for mechanical and electrical equipment plus estimated cost for foundations, station building and special facilities.

BOILER FACTOR

The boiler factor was developed from completed job data. It equals erected cost divided by the total purchase price of the boiler components. Erected cost includes indirect charges for all mechanical and electrical items that are deemed to be part of the boiler plant.

The erected "boiler plant" cost items include: Complete boiler unit including economizers, burners, air heaters and boiler supporting steel; draft fans, duct work and stacks; pulverizers, coal scales, chutes and inside conveyors, but not including coal bunkers which are part of the building; heat exchangers and pumps with drivers; tanks installed within building or on the roof; that portion of all station auxiliary electrical equipment which pertains to boilers and boiler auxiliaries, including motors, station service switchgear and transformers, cable, conduit and miscellaneous electrical accessories; valves and piping associated with the boilers; instruments, controls and gage boards associated with boiler equipment; insulation, equipment painting and preliminary operation costs.

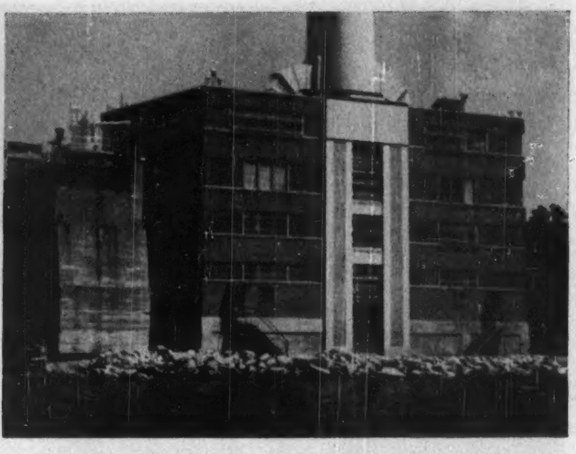
The purchase price of the boiler components covers only: Boilers including water cooled furnaces; superheaters; economizers where used; air heaters where used; burners; interconnecting duct work between above items; stokers, including overfire air systems where used; pulverizers without chutes or coal air piping; main supporting structure normally furnished to support the boiler as a part of the boiler contract; casings and buckstay systems for above components; refractory and insulation materials for all the above. Erected price was used for this last item. Boiler manufacturers normally quote erected cost for these materials even when quoting the rest of the components without erection.

Table I shows the boiler factors computed for each project investigated together with certain other basic information relating to each one.

The last two projects listed, which have been omitted in determining the weighted average factor, cover the installation of additional boilers in large existing boiler houses where most major auxiliaries had been installed on prior jobs. They are special cases and serve to illustrate the fact that these derived factors can not be used blindly and that in unusual cases engineering judgment will be required.

Table I—Boiler Factors

Job	Date	Boiler Size, Lb. per Hr.	Pressure, Lb.	Temperature, Deg. F.	Firing	Factor
C	1946	1–80,000	250	...	Stoker	3.40
E	1942	5–120,000	400	675	P.C.	3.84
B	1948	1–200,000	400	700	Stoker	3.25
A	1948	2–100,000	650	650	P.C.	3.62
F	1949	5–175,000	850	750	P.C. and gas	3.54
G	1945	3–300,000	1,250	900	Oil, gas	3.61
D	1950	2–450,000	1,250	900	Gas	3.64
Weighted average						3.61
J	1950	2–250,000	400	750	Gas	2.80
K	1949	1–300,000	1,250	900	Oil, gas	2.45



cost of the equipment. Cost for building, foundations and special facilities have been found to vary widely from job to job.

TURBINE FACTOR

The turbine factor was developed in the same manner as the boiler factor. None of the projects used included any large step-up transformers such as those often found in utility projects. The portion of station service-switchgear and transformers included in the total erected cost figure is only that portion considered chargeable to the turbine generator. The condenser and its auxiliaries do not enter into the derivation of this factor in any way.

The erected turbine and switchgear cost items include: Complete turbine generator unit including oil coolers, air or hydrogen coolers, duct work, and oil filtering system; station crane; turbine support exclusive of excavation and piling; gland seal water tank; valves and piping associated with the turbine; instruments and controls associated with turbine generator and main power switchgear; that portion of all station auxiliary electrical equipment associated with the turbine generator, including part of the station service gear and transformers, with conduit, cable and miscellaneous accessories; insulation, painting and preliminary operation chargeable to turbine generator.

The turbine and switchgear purchase price includes only the turbine generator with exciters, oil coolers and air or hydrogen coolers, plus the main power switchgear, without any station service gear or transformers.

Table II shows the turbine factors obtained for each project investigated.

Table II—Turbine Factors

Job	Date	Pressure, Lb.	Temperature, Deg. F.	No., Size and Type	Factor
L	1949	200	500	1—2 mw., auto. extr. cond., 0.6 kv.	1.91
E	1942	400	675	2—7.5 mw., induc. extr. cond., 6.9 kv.	1.54
J	1950	400	750	1—30 mw., auto. extr. cond., 13.8 kv.	1.53
A	1948	650	650	2—5 mw., auto. extr. cond., 4.2 kv.	1.51
G	1945	1,250	900	2—10 mw., back pressure, 13.8 kv.	2.16
K	1949	1,250	900	1—10 mw., back pressure, 13.8 kv.	1.76
D	1950	1,250	900	1—40 mw., auto. extr. cond., 14.2 kv.	1.54
Weighted average					1.69

CONDENSER FACTOR

Erected cost used in the condenser factor includes indirect charges. It covers: Condenser with tubes; circulating water and condensate pumps; air jets; circulating water piping to station wall; screens and that portion of the auxiliary electrical work properly chargeable to condenser auxiliaries.

Purchase price covers condenser, tubes, air jets and pumps with drives. Condenser factors are shown in Table III.

Table III—Condenser Factors

Job	Date	No.	Size, Sq. Ft.	Factor
A	1948	2	4,000	1.74
D	1950	1	37,500	1.89
E	1942	2	12,100	1.80
J	1950	1	32,500	1.90
L	1949	1	2,500	1.64
Weighted average				1.86

OTHER PROJECT COSTS

As has been stated previously the sum of the costs arrived at by use of the factors outlined will not represent total cost of a project, since no allowances have been included for the highly variable items of building, foundations and any special facilities. It is impossible to generalize about these portions of a project because of the variety of requirements.

However, it seems probable that the engineer can draw on his experience to make very fair approximations for a particular job. Building costs, for example, may range from \$0.65 to \$1.20 per cu. ft. depending on the type of construction and the extent to which the equipment is housed.

In view of the variations in these items no attempt has been made to establish a definite relationship between erected equipment cost and total project cost. Nevertheless it is interesting to note how these costs are related for an average project.

After reviewing the various projects one was selected which most nearly represented an average industrial job. Erected costs were computed using the average factors applied to equipment purchase costs. The sum of these costs was 75 percent of the actual total job cost.

SCOPE OF USEFULNESS

The average factors (boilers 3.61, turbines 1.69, condensers 1.86) which have been developed offer a quick means of arriving at a rough estimate of industrial power plant costs. Proper application of these factors should be supplemented by good engineering judgment in handling the costs for the miscellaneous additional items. It is obvious that the factors have a narrow base thus it is hoped that similar investigations will be made by other men to substantiate this work.

How to Specify Iron Water Pipe

If you have ever tangled with cast iron water pipe specifications then undoubtedly you ran afoul of trouble. Here's information to help straighten out a muddled situation.

HOWARD F. RASE

Engineers in the process industries are called now and then to select cast iron pipe for water distribution service. Invariably the man who is thrust into this job for the first time finds that the guidepost bears several signs with no indication which one to follow.

Confusion is in part caused by a situation in which an old industry continues to progress with new manufacturing methods. Yet to date there is no officially approved specification to cover modern cast iron pipe. And the specifications originally developed for pipe manufactured by older outmoded methods still linger in men's minds and continue to be printed in some of the latest textbooks.

EARLY SPECIFICATIONS

Prior to 1922 cast iron pipe was produced by stationary casting techniques where the pipe was cast in sand molds. Specifications for pit-cast pipe adopted in 1908 by the American Water Works Association (AWWA) became the industry standard for a number of years. Dimensions and thicknesses were given for bell and spigot pipe and fittings in eight classes (*A*) through (*H*). Allowable working heads in feet of water ranged from 100 to 800 ft. in 100 ft. intervals.

In 1922 the first centrifugally cast iron pipe was manufactured in this country and in the years following became generally accepted by the industry. Molten iron in this process is introduced into spinning metal molds of either the metal contact (deLavand) or sand-lined (Monocast) types. As the mold spins centrifugal force causes formation of a denser and stronger cast iron than produced by the pit casting method.

Since the great majority of all manufacturers of cast iron pipe now use only the centrifugal casting process (particularly in sizes of 4 to 24 in.) the use of the AWWA specification is not advised. It is possible to specify and obtain centrifugally cast pipe made to AWWA thicknesses. However, the AWWA pressure ratings are for pit cast pipe. The corresponding centrifugally cast pipe of the same thickness will be much stronger than required. Needless extra expense is thereby incurred.

GOVERNMENT SPECS

In order to take advantage of the greater strength of centrifugally cast pipe the government in 1931 introduced in its standard stock catalog a specification, WW-P-421[a]. This included specifications for thicknesses of centrifugally cast iron water for various internal pressures.

Types of cast iron pipe covered by the Federal specification are summarized in the latest amendment to that specification (1940) as shown below.

Type	Description
I	Centrifugally cast in metal contact molds, bell and spigot, 12 and 18 ft. lengths.
II	Centrifugally cast in sand-lined molds, bell and spigot, 16, 16½ and 20 ft. lengths.
III	Horizontally cast in green sand molds, bell and spigot, 12 and 16 ft. lengths (no longer manufactured).
IV	Cast in sand molds with bolt lugs and integral machine tapered joints, 6 an1 12 ft. lengths.
V	Vertically cast in dry sand molds (pit cast), bell and spigot, 12 ft. lengths.

Sizes range from 4 to 24 in. for two classes based on allowable internal

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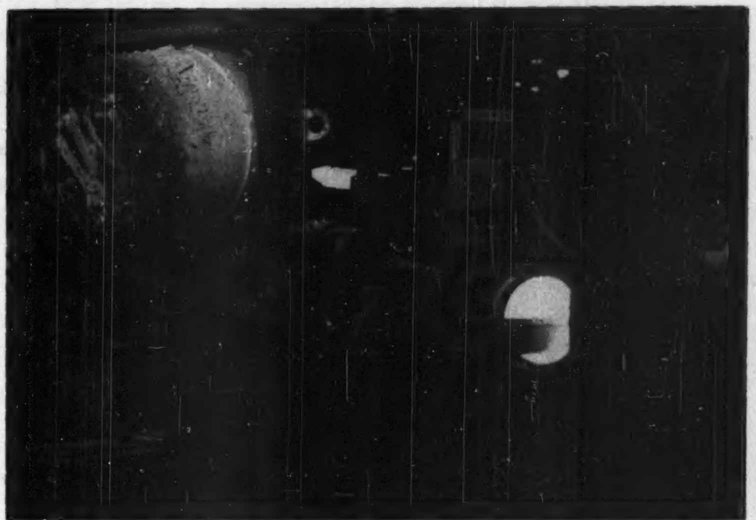
working pressures of 150 and 250 psi. (Class 150 and 250 respectively). Specified thicknesses include an allowance for water hammer using empirical modifications of the familiar thin cylinder formula. No allowance for earth or truck loads has been included in arriving at the thicknesses for the indicated internal pressures.



LADLE POURS molten iron into centrifugal casting machine to make pipe.

SOUND BASE FOR FUTURE

Eventually there will be a soundly based and universally accepted specification resulting from the work of the American Standards Association. In 1939 after 13 years of extensive research Committee A21 of the association issued a "Manual for the Computation of Strength and Thickness of Cast Iron Pipe."[2]

Outlined in this manual is the most complete available method for calculating cast iron pipe thickness under any combination of service conditions. It includes not only consideration of internal pressure and water hammer but also the external loading caused by earth pressure and passing vehicles.

Contained in Part 2 of this ASA manual are extensive tables of required thicknesses for pit cast pipe based on a bursting strength of 11,000 psi. and a crushing strength of 31,000 psi. Data are given for internal operating pressures of 50 to 350 psi. at 50 psi. intervals and depths of cover from 2½ to 16 ft. for six different laying conditions. These laying conditions are:

Condition	Description
A	Flat bottom trench, backfilling not tamped.
B	Flat bottom trench, backfilling tamped.
C	Pipe supported on blocks, backfilling not tamped.
D	Pipe supported on blocks, backfilling tamped.
E & F	Seldom used for water pipe.

In like manner Committee A21 is preparing similar tables and specifications for both types of centrifugally cast pipe. These are being based on a bursting strength of 18,000 psi. and a crushing strength of 40,000 psi. At present they are tentative specifications and have not been issued.

Various manufacturers[1, 4] have presented, in their catalogs, tables of manufacturers' standard thicknesses. These thicknesses were determined using the ASA method and the 18,000/40,000 strengths for centrifugally cast pipe.

Such tables, although not yet a part of the approved cast iron specifications, are valuable for estimating the required thickness of cast iron water pipe under various conditions of internal pressure and external loading. They obviate the necessity for detailed calculations.

A portion of such a compilation is reproduced in the accompanying table. These values are for laying condition B which is the most common condition prevailing on industrial service.

Final clarification of the specification muddle will not occur until approved specifications for centrifugally cast pipe are issued by the American Standards Association. During the interim period pipe can be selected correctly by using a combination of methods. Thickness required for a given job can be calculated by the method of ASA 21.1 or determined from tables based on this method for 18,000 psi. bursting strength and 40,000 psi. crushing strength. Once the thickness is determined it can be specified in terms of Federal Specification WW-P-421 using the class (150 or 250) having a thickness nearest to the calculated value.

Standard Thicknesses for Centrifugally Cast Iron Water Pipe

Nominal Pipe Size, In.	Internal Working Pressure, Psi. 50	100	150	200	250	300
	Pipe Wall Thickness, In.					
3	0.32	0.32	0.32	0.32	0.32	0.32
4	0.35	0.35	0.35	0.35	0.35	0.35
6	0.38	0.38	0.38	0.38	0.38	0.38
8	0.41	0.41	0.41	0.41	0.41	0.41
10	0.44	0.44	0.44	0.44	0.44	0.48
12	0.48	0.48	0.48	0.48	0.52	0.52
14	0.48	0.51	0.51	0.55	0.59	0.59
16	0.54	0.54	0.54	0.58	0.63	0.68
18	0.54	0.58	0.58	0.63	0.68	0.73
20	0.57	0.62	0.62	0.67	0.72	0.78
24	0.63	0.68	0.73	0.79	0.79	0.85
30	0.79	0.79	0.85	0.92	0.99	....
36	0.87	0.87	0.94	1.02	1.10	....
42	0.97	0.97	1.05	1.13	1.22	....
48	1.06	1.06	1.14	1.23	1.33	....

Basis: Laying condition B: Flat bottom trench, tamped back fill. Depth of cover: 5 ft. Strengths of iron: 18,000 psi. bursting tensile, 40,000 psi. modulus of rupture. Method of calculation: ASA A21.1. Figures for this table are from complete tables published by the American Cast Iron Co., Birmingham, Ala., in their "American Pipe Manual" (14th Edition, 1951).

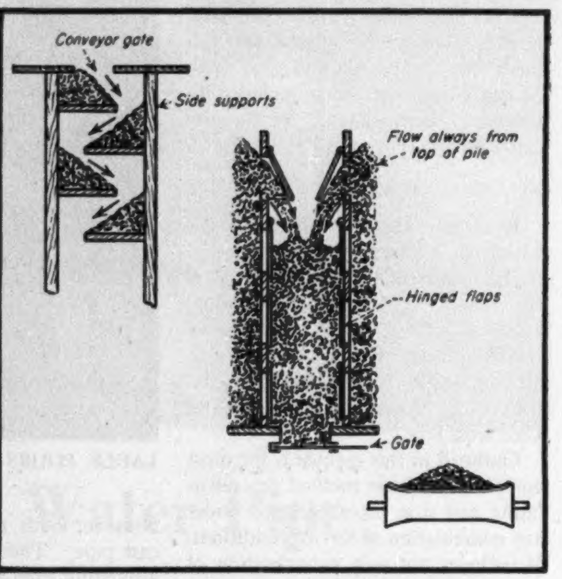
ACKNOWLEDGEMENT

The author wishes to thank the American Cast Iron Pipe Co. for permission to reproduce portions of a tabulation contained in their publication[1] and Thomas F. Wolfe, director of the Cast Iron Research Association for his helpful comments.

REFERENCES

1. "American Pipe Manual," 14th Edition, 1951, American Cast Iron Pipe Company, Birmingham, Alabama
2. ASA 21.1—1939 "Manual for the Computation of Strength and Thicknesses of Cast Iron Pipe," American Standards Association
3. Federal Specification WW-P-421-1931 and 1940 (amendment), "Pipe: Water, Cast-Iron (Bell and Spigot and Bolted Joint)," Standard Stock Catalog, Washington, D. C.
4. "Pipe Economy," No. 41-1949, Clow-National, James B. Clow and Sons, Chicago, Ill.

About monoxide . . .



. . . Chutes, bins and idlers

Materials-Handling Tricks

You will benefit from these reminiscences from an authority on materials handling. His experiences will suggest methods you can use to prevent equipment failure and loss of production.

WILBUR G. HUDSON

Phoned the purchaser: "Your crusher won't do the job. It needs a 20-hp. motor." He had bought a crusher for tough chrome ore, with an exceptionally heavy flywheel and V-belt drive from a 5-hp. motor. Inspection showed the obvious. He had the crusher motor interlocked with the feeder motor and the big lumps tumbled into the rolls before they had a chance to build up speed. So, of course the crusher objected.

PROVIDE FOR SLACK

A kick came from another purchaser: "Your conveyor is no good. The chains have parted six times in the past month." A quick check showed nothing wrong with the design. It was a roller-flight conveyor inclined upward at 10 deg. with two strands of #698 rivetless chain rated at 100,000-lb. ultimate. The estimated load on each chain was 7,000-lb. Investigation showed that each break had occurred when the loaded conveyor was started after an emergency stop with the conveyor loaded.

These rivetless chains are unique in that the links are collapsible, or back into each other. The 10 deg. inclination was not enough to cause the loaded conveyor to reverse and when the power was cut off, the chain tension swung the head sprockets backward a turn or so and the links in the five or six feet of chain adjacent thereto telescoped. When power was applied this slack was snapped out. A solenoid brake left the purchaser contented.

AVOID FLARED IDLERS

An Ohio chemical plant wrote they were having trouble with their new belt conveyor. The belt was wearing rapidly and the power requirement was so excessive they had to mount a fan alongside the motor in an effort to keep it cool. We checked their order, which had covered the head and foot assemblies and 24-in. belt. They had "in stock the necessary carrying and return idlers." Everything checked O.K. so the writer went for a check-up.

The machine was certainly taking a lot of power. The motor was running dangerously hot. The underside of the belt showed serious abrasion along both edges. Then it was noticed that the carrying idlers were the old flared type

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W. G. HUDSON *is a consulting engineer and author of numerous articles on materials handling subjects.*

that was brought out back in 1916. They were low in price but had a brief existence. I had not seen one in years.

The trouble with this idler is that with the load resting on the belt the rotation of the idler is determined by the diameter of the cylinder, and the flared ends move faster than the sections of the belt against which they are pressed causing a continuous slip, evidenced by the high polish of the flared ends. Customer requested that a set of modern 3-pulley idlers be shipped by express at once.

USE AIR BLAST

The purchasing agent at an Iowa chemical plant complained that the continuous flow elevator we had sold them for handling ammonium nitrate would not work. He was right. The material fed in all right, but absolutely refused to discharge at the top. The loads could be brushed off by hand but they stuck just enough to carry on into the down run—so the load carried round and round. I commented sadly to the plant engineer that if we only had a source of compressed air we could jet the loads out. Luck was with us. In adjacent room was an idle ½-hp. compressor. It was an easy matter to run a pipe up to the elevator head and arrange two ⅛-in. jets directed against the element. Discharge then was perfect.

PREVENT PELLET BREAKDOWN

Up in Michigan we provided an overhead slow speed conveyor to gently deliver fragile pellets about the size of walnuts to a series of storage bins. To minimize breakage so far as possible, a retarding chute was provided at each conveyor gate (see cut) so the material trickles downward to the top of the pile in the bin. That worked out very well. Of course there was some degradation as was to be expected.

The pellets were discharged from the bins to cars beneath. Degradation at that point was very bad. The converging flow of the mass to the discharge gate ground up the pellets so they were rather hard to find in the carloads.

An old device we used years before in sized-anthracite retail coal pockets came to mind. A rectangular box leading up from each discharge gate was fitted with hinged flap gates spaced about two feet apart. The outflow from the bin, when the gate is opened, is always from the crest of the pile in storage, and grinding action is practically eliminated.

USE CARE WITH TRUCKS

The rapidly growing use of motorized industrial trucks in and around the plant has introduced a source of mishaps to personnel, equipment, and structures. Truck operators are dependent on the operator's skill. Some are competent, some are careless. Rather curiously, employers find the veteran or old-timer operators are the more difficult to improve. They seem to resent suggestions. The younger trainees, both men and women, learn faster and make better operators.

There is some objection to gasoline-powered trucks inside the plant because of carbon monoxide in the exhaust. A recent development seems to have substantially reduced this objection. It is a catalytic apparatus introduced into the exhaust in place of the usual muffler. It is applicable only to unleaded gasolines and primarily to trucks having an engine piston displacement of from 190 to 240 cu. in.

The exhaust manifold has a venturi air inlet which introduces fresh air into the exhaust gas stream to provide the oxygen necessary for the conversion of CO into harmless CO_2 when passed over multiple "sticks" of porcelain coated with a thin film of platinum, which is the catalyst. The Underwriters Laboratories have approved the device as "performing with reasonable effectiveness in reducing exhaust gas hazards when properly installed, operated and serviced." Many users and the principal manufacturers of these trucks are now equipping some machines with this device.

WATCH DUST HAZARDS

A mishap, or rather a disaster circumstance, of growing seriousness is that inherent in the expanding use of materials which have dusts with an affinity for oxygen. Consider this grim statement four years ago by C. O. Dicken, vice president of the Brach Candy Co., Chicago, regarding the dust explosion that wrecked his plant:

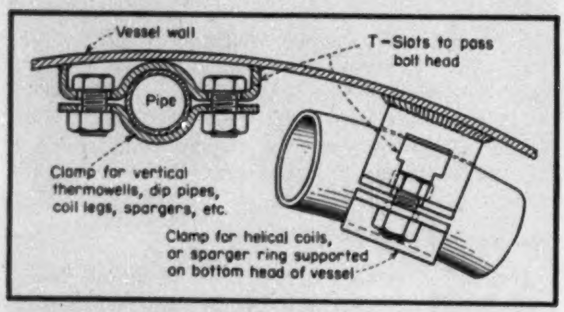
"In the early morning of Sept. 7th, 1948, nineteen cooks and machine operators reported for work between 3:30 and 3:45 A.M. They changed their clothes and proceeded to their work stations on the third and fourth floors. The printing and casting machines were being checked and made ready for the start of operations. The cooks were preparing for their first batches of candy. Suddenly there was a strange noise like rushing air. Then came the blast. Almost simultaneously there was a sheet of flame engulfing the area. Then came a series of explosions on the third and fourth floors which blew out windows and exterior walls, followed by a flash fire of extreme intensity which ignited wood starch trays, the starch in them, and cork insulation. Fortunately, because of the early hour, only 43 employees were on the property. There were 19 in the area involved. Only one survived. The fire marshal gave as his opinion that a small fire was in progress prior to the explosion, basing his opinion on displaced fire extinguishers and a small un-reeled hand hose. Probably an effort to put out a small blaze stirred up starch dust accumulations, thus forming an explosive dust-air mixture."

The dangerous possibilities in the mechanical handling of coal and grain dusts have long been recognized, but the dusts from starch, sugar, plastics, aluminum and magnesium have possibilities far more serious. Risks involved in the dusts of materials entering into the investigations of the Atomic Energy Commission, notably titanium, thorium, uranium, and the hybrides of these metals, have such potential hazards that operations are conducted in an atmosphere of carbon dioxide or nitrogen. Their explosive violence, as measured by the rate of pressure rise, extends up as high as 10,000 psi. per sec. as compared with 780 lb. maximum for coal dust explosions.

The plant material handling equipment is important. When it suffers breakdown other operations are affected, or sometimes all operations cease. Mishaps can be eliminated by on-the-job training of the man or men whose work includes responsibility for the operation and maintenance of equipment involved. If he is indoctrinated in the things he must watch, the adjustments he must make, abuses by others that he must prevent, then a well-designed material handling installation will function for thirty years or more with very little up-keep expense.

The Plant Notebook

Edited by Theodore R. Olive



Clamp Simplifies Support of Pipe and Coils in Vessels

STANLEY YOKELL, *Chemical and Professional Engineer, Fairlawn, N. J.*

★ **March Contest Prize Winner**

In the construction of process vessels, the problem of how to support internal cooling or heating coils and other pipe or tubing appurtenances often arises. Common methods in use include (1) Bolting U-bolts to clips, straps or saddles; (2) internal pipe or bar framework; and (3) clips welded to the vessel wall. In method 3 nuts are welded on to the clips to receive bolts that pass under the turns of the coil and through a vertical strap on the inside diameter of the coil.

Methods 1 and 2 require that there be sufficient space between the outside diameter of the coil and the vessel wall to permit a workman's arm and wrench to reach the nuts behind the coil. The pitch of the coil must be set by the same considerations.

Method 3 has the disadvantage that when the nuts become corroded or burred, they must be chipped loose and replaced, which requires chipping and welding in an inaccessible location.

All of the ordinary methods have the disadvantage that contact between the coil and its supporting members occurs on a line only. Where extremes of temperature are encountered the supporting points become crushed and erroded because of the expansions and contractions that take place. The useful coil life is thus shortened. In addition to the foregoing, care must be taken to avoid excessive tightening of bolts to prevent crushing, crimping and cracking prior to putting the unit into service.

The sketch illustrates a clamp which can be fabricated on a press brake in one stroke. By standardizing on sizes, production quantities can be made cheaply. Because of the ease of installation a labor saving is achieved. Other advantages are that coil pitch can be small and clearance between the vessel wall and the outside of the coil is not limited by accessability, but only by the physical dimensions of the bolting and clamp materials used.

HOW CLAMP IS MADE

The clamp consists of a channel section with a cylindrical depression in the web; and a flat, rectangular section of equal length with a mating cylindrical depression. Clearance is permitted between the saddle section and cover to permit tension to be applied to the bolts. The flanges of the channel are provided with a T-slot, with the leg of the tee extended around the corner into the web as far as the bolt location. The cover piece is drilled or punched to pass the bolt, the nut fitting over the cover piece. The saddle sections are located in the vessel prior to coil insertion, and welded to the wall as shown after making the appropriate location layout. After the coil is in place, temporarily supported by blocks or other rigging, the heads of the holding bolts are slipped into the T-slots, the shanks of the bolts passing through the slot extensions in the flange of the channel. The cover is slipped over the bolts, the nuts run on and tightened and the operation is complete.

Added refinements, not shown in the sketch, include (1) tack welding a tit to the underside of the web of the channel to prevent the bolt from rotating before sufficient tension is exerted to accomplish this by friction and (2) grinding the edges of the web with a pencil grinder to give additional conformity with coil shape and prevent cutting of the coil by the clamp edges.

How to Insure Correct Lubrication

At the recent Maintenance Conference held in Cleveland this winter, one chemical concern described a simple method used to prevent the wrong kind of lubricant from being used. A different size grease fitting is used for each kind of grease. Each part to be lubricated is provided with the size fitting corresponding to the kind

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★ **April Contest Prize Winner**

"How Curves Can Simplify Estimation of Coil-in-Tank Cooler Performance."

A prize of $50 in cash will be awarded to R. S. Cook, chemical engineer, Zaremba Co., Buffalo, N. Y. Mr. Cook's article will be published in the Plant Notebook section of the July issue.

$50 PRIZE FOR A GOOD IDEA—Until further notice the Editors of *Chemical Engineering* will award $50 cash each month to the author of the best short article received that month and accepted for publication in the Plant Notebook. Each month's winner will be announced the second following month and published the third following month.

$100 ANNUAL PRIZE—At the end of each year the monthly winners will be rejudged to determine the year's best Plant Notebook article, which will then be awarded an additional $100 prize.

HOW TO ENTER CONTEST—Any reader of *Chemical Engineering*, other than a McGraw-Hill employee, may submit as many entries for this contest as he wishes. Acceptable material must be previously unpublished and should be short, preferably not over 500 words, but illustrated if possible. Articles which are acceptable but are not winners will be published at regular space rates ($10 minimum).

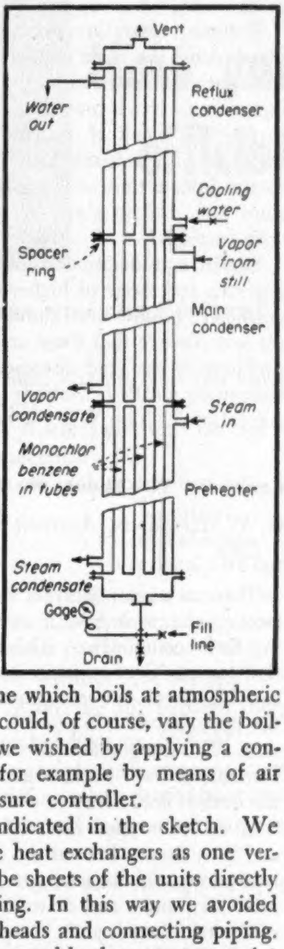
Articles may deal with plant or production "kinks," or novel means of presenting useful data, which will interest chemical engineers. Address Plant Notebook Editor, *Chemical Engineering*, 330 West 42nd St., New York 36, N. Y.

of grease required. Hence only the gun containing the correct grease can be applied to the grease fitting on any particular piece of equipment.

Boiling Liquid Coolant Prevents Condensate Freeze-Ups

JOSEPH I. LACEY, *Chemical Engineer, Hooker Electrochemical Co., Niagara Falls, N. Y.*

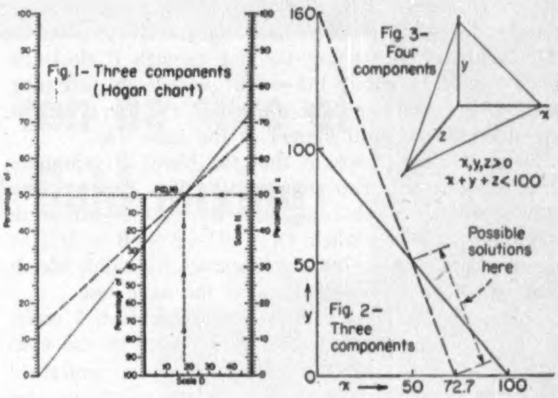
We recently had the problem of condensing a high-boiling distillate which condensed at about 150 deg. C., but which would freeze if allowed to cool below 130 deg. C. Thus it was necessary to use a heat transfer medium which could be controlled in temperature so that the condensate could not freeze, and yet it was necessary to extract heat from the medium to give the desired rate of condensation.



The decision was to go to a boiling liquid coolant which would boil close to, but above the freezing point of the condensate, so as to get as much temperature head as possible between the coolant and the condensing product. We chose monochlor benzene which boils at atmospheric pressure at 132 deg. C. We could, of course, vary the boiling point of the coolant if we wished by applying a constant pressure to the vent, for example by means of air supplied by a constant pressure controller.

The design we used is indicated in the sketch. We installed three shell-and-tube heat exchangers as one vertical unit, connecting the tube sheets of the units directly together through a spacer ring. In this way we avoided the use of the intermediate heads and connecting piping. The tube side is filled with monochlor benzene to a point about two-thirds of the way up the middle unit. A pressure gage attached to the bottom head shows the level of liquid in the tubes. Cooling water is connected to the shell side of the top exchanger so that it serves as a reflux condenser for the monochlor benzene. Vapors from the still are brought to the shell side of the middle exchanger which serves as the condenser. Steam is connected to the shell side of the bottom exchanger to allow preheating of the monochlor benzene on start-up.

During normal operation water runs through the top exchanger, but there is no steam on the bottom exchanger. Vapors from the still enter the middle unit at the top, exchange heat with the monochlor benzene, condense, and leave from the bottom. The monochlor benzene absorbs heat at its boiling point of 132 deg. C., boils, and its vapors condense in the top exchanger, or reflux condenser, returning to the middle unit. In a cold start, steam is put on the bottom section so as to preheat the monochlor benzene to its boiling point before the still vapors are admitted to the middle section. In this way any possibility of over-cooling and freezing the condensate is averted.



More on Blending of Three or More Components

NOTE: *Joseph T. Hogan's Plant Notebook article, "Chart Helps Find Blend Composition for Three Components," which appeared on p. 174 of our February 1953 issue, has brought forth comment from two readers. Dr. Condon shows how to extend the idea to determining minimum cost of blends, how to use a simple rectangular plot for three components, and how to handle four components in a three dimensional plot. Mr. Upington introduces a simplification in finding the pivot point on the Hogan chart. Refer to the original article for a chart of usable size.*—EDITOR.

Comment I—Five New Aspects

EDWARD U. CONDON, *Director of Research, Corning Glass Works, Corning, N. Y.*

With respect to Mr. Hogan's article, finding the pivot point P (see Fig. 1) can be simplified. Where x, y and z are the weight percentages of the three components to be blended, and a, b and c are the weight fractions of some common component (e.g., moisture) contained in the three materials, let it be desired to produce a blend in which d is the weight fraction of the common component in the final product. Then a simple calculation shows that the coordinates of P in terms of N and D (see Fig. 1) are

$$N = \frac{100\,(d - c)}{a + b - 2c} \qquad D = \frac{50\,(a - b)}{a + b - 2c}$$

and a series of lines through P on the chart, intersecting the scales for x, y and z, will show the various possible blend compositions.

The location of P may come out in such a way that no line can be drawn through it corresponding to non-negative values of x, y and z. This means that the desired value of d cannot be obtained by any possible blend of

the three given components. Usually if the problem is solvable at all, there will be a range of possible blends.

Suppose that the cost of a unit weight of the three components is A, B and C, respectively. Then $(Ax + By + Cz)$ is the cost of 100 lb. of the desired blend. If we substitute for x, y and z in terms of k, the slope of the line, N and D, we find this cost to be

$$100\,C + N(A+B-2C) + k\,[50(A-B) - D(A+B-2C)]$$

If the coefficient of k is positive, then minimum cost requires that k be made as small algebraically as possible. This is found by rotating the line through P clockwise until limited by one of the weight percentages becoming zero. If the coefficient of k is negative, the line is rotated counterclockwise until limited in the same way.

Thus it always happens that the blend of minimum cost contains only two components. This gives an easy way of finding which component not to use—except in the very special case where $(A - B)/(A + B - 2C) = (a - b)/(a + b - 2c)$. In this case all possible blends leading to the desired result are of the some cost.

Although the nomograph is very convenient, I prefer to use a simple graph as in Fig. 2. Since in real cases x, y and z are all greater than zero, we are only concerned with the triangular area bounded by the coordinate axes and the diagonal line joining the points (0,100) and (100,0). A straight line having the equation $(a - c)x + (b - c)y + (c - d)100 = 0$ represents the values of x and y that satisfy the problem. For any given values of a, b, c and d this line may be drawn easily by joining the points

$$\left(100\,\frac{d-c}{a-c}\,,\,0\right) \text{and} \left(0,\,100\,\frac{d-c}{b-c}\right)$$

Fig. 2 shows such a line (dashed) for Mr. Hogan's conditions, where $a = 18$, $b = 12$, $c = 7$ and $d = 15$. If this line does not cross the triangle, the problem has no solution. If it does, then any point that is on the line and within the triangle is a possible solution.

Likewise, the cost function becomes

$$P = 100\,C + (A - C)\,x + (B - C)\,y$$

which enables straight lines of constant cost to be drawn readily, in order to see which end of the range of solutions corresponds to the blend of least cost.

FOUR-COMPONENT BLENDS

This method is applied easily to a solution of the same problem for four-component blends. When the four percentages are x, y, z and u, then

$$x + y + z + u = 100$$

Eliminating u and letting e equal the percentage of the desired material in component u, we can make an ordinary three-dimensional x-y-z chart in Cartesian coordinates. All possible solutions must lie inside the rectangular tetrahedron (Fig. 3) defined by the conditions that x, y and z are all greater than zero, but their sum is less than 100. The analog of the straight line in the three-component case is the plane

$$(a - e)\,x + (b - e)y + (c - e)\,z + (e - d)\,100 = 0$$

If this plane does not cross within the tetrahedron, then the problem has no solution. If it does, then any point on the plane and within the tetrahedron is a possible solution.

The cost function becomes

$$P = 100E + (A - E)\,x + (B - E)\,y + (C - E)\,z$$

where E is the cost per unit weight of the fourth component. The lines of constant cost in the three-component example now become planes normal to the vector L whose direction cosines are proportional to $(A - E)$, $(B - E)$ and $(C - E)$. The possible blends lie on a plane normal to the vector M whose direction cosines are proportional to $(a - e)$, $(b - e)$ and $(c - e)$.

If these vectors are parallel it shows that all possible blends have the same cost. If not, it is easy to tell from the relative orientation of the vectors L and M in which direction to move toward the surface of the tetrahedron to find the blend of minimum cost. We must move in the plane of permissible blends in a direction perpendicular to the intersection of this plane with the planes of constant cost, and in a sense which makes an obtuse angle with vector M.

Similar considerations apply with more than four components, and space of higher dimensions, except that the geometry becomes much more difficult to perceive. Finally we may observe that these are trivially simple examples of problems of the kind discussed in a book edited by T. C. Koopman, entitled "Activity Analysis of Production and Allocation," (John Wiley & Son, New York, 1951).

Comment II—About the Pivot Point

G. W. Upington, *Assistant Research Engineer, Lennox, Calif.*

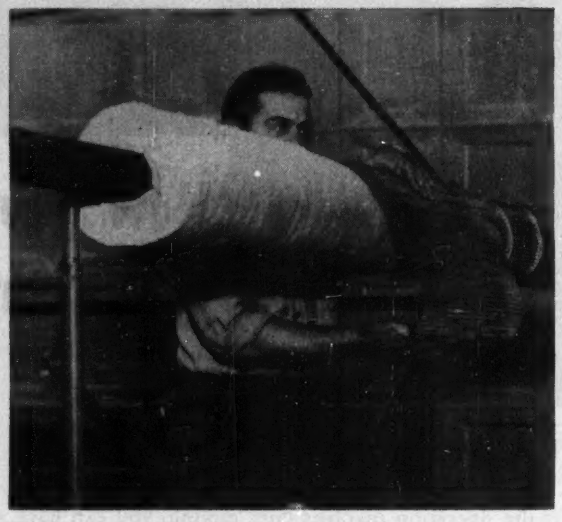
There is a simplification that can easily be applied to locating the pivot point P in Mr. Hogan's chart for blending three components. This takes advantage of the fact that for any final moisture content it is possible to make two blends of two components. By proper selection of the designations it is possible to let y and z in turn equal zero. The designations should be such that the moisture contents of both y and z are either greater or less than d, the desired final moisture content in the blend.

If we let y equal zero, we can easily solve for x and z and then draw a line on the chart (Fig. 1) through these two points. Then, letting z equal zero, we can similarly solve for x and y and draw a second line. The intersection of the two lines is at P, the pivot point. Using the conditions in Mr. Hogan's problem, when z is zero, then inspection shows $x = y = 50$ percent. When y is zero $18\,x + 7z = (x + z)15$, and $x + z = 100$. Solving, $x = 72.7$ and $z = 27.3$. The lines between these corresponding values (fine dots in Fig. 1) then locate pivot point P at the same position found by Mr. Hogan. Of course, in this particular case it was possible to find one line by inspection. But in any case, there will be but two manipulations involved, each the solution of two simultaneous equations.

In this way we avoid the manipulations with N and D and hence do not need the N and D scales. However, location of P is admittedly less accurate than by Mr. Hogan's method since the lines do not intersect at P at right angles. But the method does seem a little more straightforward.

NEW MATERIALS OF CONSTRUCTION

FIRST you wrap the flexible glass blanket around pipe.



THEN you install the outer protective jacket.

Pipe Wrapped in Glass Blanket

. . . conveys hot and cold fluids with minimum heat loss. Blanket is flexible, economical and durable. Material can insulate complete system including fittings.

A recently announced Fiberglas wrap-around pipe insulation marks a broad step away from conventional practice of insulating hot or cold pipe lines with rigid materials.

Flexibility of the Aerowrap insulation makes it easy to apply on flanges, fittings and valves as well as to hot and cold pipes of all sizes. Fine glass fibers bonded with a special binder make Aerowrap soft and resilient giving it a high heat-saving thermal efficiency.

Aerowrap's resilient nature makes it easily compressible for savings in storage space. Once compression is released the material springs back to its original volume. This resiliency also enables Aerowrap to absorb physical abuse without damage.

It is said heat savings range up to 25 percent better than offered by equal thicknesses of most rigid insulations. Low material cost and less than normal application expense combine to cut over-all costs over conventional applications. Labor savings increase appreciably where many valves and fittings are involved.

Aerowrap is furnished in 100-ft. rolls, 36 in. wide and either ¾ or 1½ in. thick. Blankets can be cut to desired length either on the job with a knife or straight edge, or in the maintenance shop with a long paper or sheet metal cutter.

To install the blanket it is merely wrapped around the pipe and fastened either with staples, adhesive or Fiberglas cord tied on 6-in. centers.

In applying Aerowrap around a fitting the material should be cut to a width about equal to the fitting diameter. The material is then spirally wound around the fitting to a thickness slightly greater than adjoining insulation. Open mesh glass fabric is then wound over the Aerowrap to tighten it down to the same thickness as the adjoining insulation. A layer of asphalt mastic followed by a layer of traffic, aluminum, or asphalt base aluminum paint completes the job.

Any one of four different kinds of protective jackets may be installed over the insulation. Jacket material may be selected either from black roofing felt, white asbestos paper-faced felt, corrugated aluminum sheet or rolled galvanized sheet metal. Jackets may be held in place by wires, bands, staples or screws, depending upon the type of jacket selected.

Two limitations on the use of this material relate to temperature conditions. Use is not recommended on pipelines over 600 deg. F. On cold lines a sealed vapor-barrier jacket is required to prevent condensation, frost or icing on pipes. Vapor barrier is applied over the Aerowrap and for lines that are not subjected to abuse provides a sufficient jacket. However, outdoor or indoor lines may be finished by using any one of the four jackets mentioned above.

A recommended vapor barrier jacket consists of aluminum foil laminated between kraft paper. This material, furnished by the manufacturer, must be sealed around the glass blanket with a good vapor barrier adhesive. The barrier has a vapor transmission rate of less than 0.01 perm. Jacket comes in 36 in. by 300 ft. rolls and 4 in. by 300 ft. joint sealing strips. Adhesive is in one or five gal. cans.—*Owens-Corning Fiberglas Corp., Toledo 1, Ohio.*

Equipment Cost Indexes

(Marshall & Stevens Indexes, 1926 = 100)

Industry	Mar. 1952	Dec. 1952	Mar. 1953
Average of all	180.2	180.8	180.7
Process Industries			
Cement mfg.	172.8	173.0	172.7
Chemical	180.8	181.4	181.1
Clay products	167.8	168.0	167.7
Glass mfg.	170.9	171.4	171.1
Paint mfg.	174.1	174.7	174.4
Paper mfg.	174.4	175.0	174.7
Petroleum ind.	177.2	178.1	177.8
Rubber ind.	179.6	180.5	180.2
Process ind. avg	178.2	178.9	178.6
Related Industries			
Elec. power equip.	182.4	183.3	183.0
Mining, milling	181.5	182.4	182.1
Refrigerating	200.3	201.2	201.0
Steam power	170.0	171.0	170.7

Compiled quarterly for March, June, September and December of each year by Marshall and Stevens, evaluation engineers, Chicago and Los Angeles. Indexes are prepared for 47 different industries, from which the eight process and four related industries listed here are selected. Published each month with the latest available revision. For a description of the method of obtaining the index numbers see R. W. Stevens, **Chemical Engineering,** Nov. 1947, pp. 124-6. For a listing of annual averages since 1913 see **Chemical Engineering,** March 1953, pp. 220, 221.

IN BRIEF—A capsulated listing of this month's newsworthy equipment.

Compressible Gasket Resists Heat

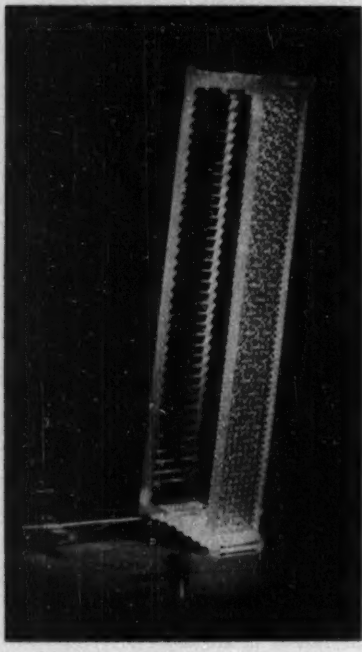
Asbestoprene gasket material formulated of asbestos and neoprene synthetic rubber combines compressibility with heat resistance. By combining these two properties in one material the manufacturer has filled a gap in the line of gasketing materials between compressed asbestos sheet and cork or rubber.

Previous applications requiring this combination of properties have been satisfied by use of glue-glycerine treated paper. Asbestoprene is more compressible and heat-resistant than glue-glycerine paper. In addition it has much better dimensional stability, does not cause corrosion of light metals and is resistant to oils, water, gasoline and anti-freeze solutions.—*Victor Mfg. and Gasket Co., 5752 Roosevelt Rd., Chicago, Ill.*

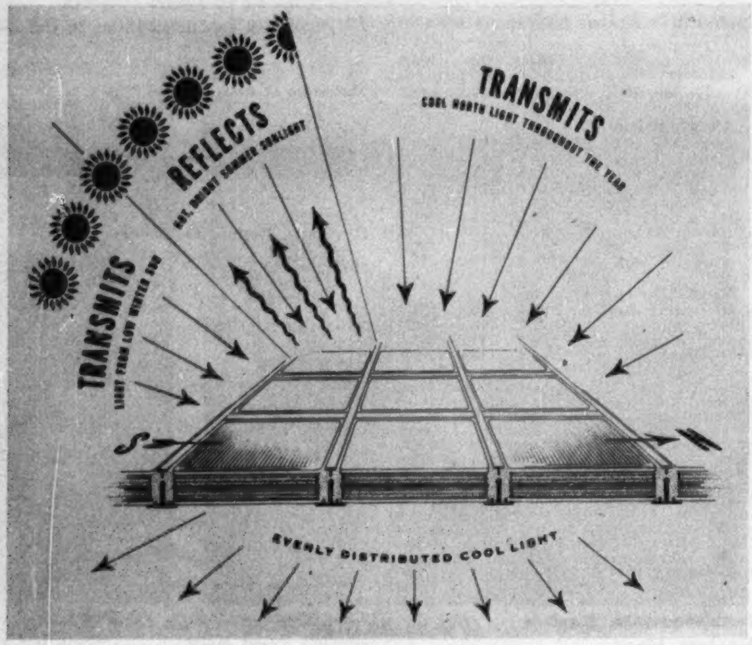
Copper Cladding Widens Steel's Utility

Copper clad steel available as a new engineering material for use in industrial equipment combines the advantages of both copper and steel in plate form. The specialized corrosion resistance, electrical and thermal conductivity of copper have been retained in combination with the strength, rigidity and economy of steel. This combination of properties makes the material well suited for use in evaporators, condensers, tube sheets, heat exchangers, hot water heaters, kettles, tanks and pressure vessels.

Two types of copper clad steel are regularly furnished: Oxygen-free high conductivity copper; and phosphorus deoxidized copper for good welding. The clad steel in plate form is available in sizes up to 120 in. wide by 380 in. long and from 3/16 to 1½ in. thick. Cladding percentages, specified as percentage of total composite plate thickness, can be 10, 15 or 20 percent. —*Lukens Steel Co., 604 Lukens Bldg., Coatesville, Pa.*



SAWTOOTH surface screens sunlight.



INTENSE RAYS of sunlight are reflected, other cool light is transmitted.

Skylight Conditions Sunlight

Here's a skylight panel that will reject much of that scorching summer sunlight, yet pass the welcome rays of December. It's a new step in conditioning sunlight.

Remarkably uniform admission of solar light and heat through flat roof skylights is claimed for the Toplite panel. The overbearing brightness of an August high noon is choked down to the same intensity you would find under your favorite shade tree on the same day.

Flip the calendar over to mid-winter when the sun at noon hangs low in the sky and you will find Toplite transmitting approximately the same amount of light. In summer a large part of the light is reflected; in winter most all the light is transmitted.

This selective quality is built in. No manual adjustment is needed. All that is required is to properly orient the panels when they are installed. Then as the sun's elevation changes with the seasons, control of light entry is automatic.

Construction of the glass units in the panel is shown above. Each unit is a hermetically-sealed hollow glass box measuring 10$\frac{3}{8}$ in. square by 3 in. thick. Space within the box has been evacuated for insulating purposes.

Top and bottom surfaces of the box have been designed to perform specific functions. Prisms on the inside of the top glass govern the amount of daylight and solar heat transmitted to the interior according to the location of the sun. The bottom piece of glass has an uneven surface to diffuse the entering light and distribute it evenly to the area below. A sheet of Fiberglas 0.002 in. thick is mounted in the space between top and bottom glasses. This sheet is said to soften light transmitted through the unit and augment the insulating effect of the vacuum.

Prefabricated panels are assembled by mounting several of these glass units in properly insulated aluminum grids. A hot tar and sulphur compound seals all units together, making a finished weather-proof panel.

Panels must be installed oriented within 30 deg. either side of the north and south axis. A pitch of $\frac{1}{4}$ in. to the foot in either east, north or west directions provides ample drainage. An installation installed in this fashion will perform as shown in the diagram above.

High light-transmission comes from the north half of the sky and from the lower part of the south sky. A high transmission of daylight from these areas is desirable. Its intensity on the horizontal surface is relatively low and does not result in problems of glare or solar heat.

Low transmission of daylight comes from the section of sky which contains the hot bright summer sun. Prism design on the underside of the top glass reflects back a large percentage of direct sunlight from this sector of the sky. This rejection of hot summer sun results in lower solar heat gain and eliminates high brightness.

Illumination performance of the panels has been measured in a full size test building constructed by the daylight laboratory at the University of Michigan. Detailed illumination data from these tests is now available to interested parties.

Completed panels weigh 16 lb. per sq. ft. and are made in four stock sizes; 3x3 ft., 4x4 ft., 4x5 ft., and 3x6 ft.—*Kimble Glass Co., Toledo 1, Ohio.*

Hydrocyanic Acid Gas Detected in Atmosphere

Where there is any possibility of personnel exposure to toxic concentrations of hydrocyanic acid gas in the atmosphere you can avoid trouble by use of a small detecting instrument. A quick reading is easily made by squeezing the aspirator bulb three times to draw in an adequate air sample.

Any HCN present reacts with reagent granules in the detector tube turning them blue beginning at the end where the air sample enters. Length of travel of this coloration increases with the percentage of HCN in the air. Concentrations from 0 to 50 ppm. may be read on the graduated scale of the detector tube.—*Mine Safety Appliances Co., Braddock, Thomas and Meade Sts., Pittsburgh, Pa.*

Quick Opening Valve Fits Safety Needs

Need for quick opening, emergency-service valves has fostered the development of a new piston-operated unit. Uses for this valve range from opening flow into quench lines, sprinkler, fog or spray systems, to dumping process vessels into outside storage in times of plant fire. Control may be either manual or remote in combination with fire fused seals, pneumatic controls, or solenoid controls.

The valve is held in closed position by piston pressure. Release of this pressure permits instantaneous opening of the disk by line pressure force behind it. Rapid closure depends on piston pressure working against line pressure.

Sentry piston-operated quick-opening valves are rated at 250 psi. Units may be installed in any position.—*The McRae Corp., 621 South Spring St., Los Angeles, Calif.*

Cover Goggles Fit Over Glasses

A new line of cover goggles made to fit over modern glasses are 20 percent larger than previous models. Designed for use by both chippers and welders, the molded plastic frames have wide bearing surfaces to eliminate local pressure. Standard 50-mm. lenses are quickly replaceable from the front. Both direct and indirect ventilation, coupled with larger air spaces within the goggle, reduces fogging.—*Chicago Eyeshield Co., 2300 Warren Blvd., Chicago, Ill.*

Warning Labels Apply Easily, Resist Wear

Warning labels for containers of hazardous materials are now made of strong cotton cloth coated with a resistant silicone film. Labels stick fast to glass, metal, wood, plastic or ceramic containers without moistening.

Quik-Label container markers are furnished completely printed mounted on dispenser cards in groups of three. Black lettering stands out vividly from the sharply contrasting caution-yellow background.

Where desired, markers can be furnished with a blank space for insertion of a self-sticking label for a specific material. Thirty-six different wordings are available on stock container markers. Insert-cards with names of most hazardous materials in general usage are available from stock.—*W. H. Brady Co., 727 West Glendale Ave., Milwaukee 12, Wis.*

Aromatic Detector Protects Workers

Atmospheric contamination by aromatic hydrocarbons can be a menace to personnel. Benzene, toluene and xylene present in the atmosphere are readily detected by the MSA aromatic hydrocarbon detector. Low concentrations of these materials produce a specific color reaction within the instrument.

Tests have indicated satisfactory detection without interference in the presence of turpentine, petroleum ether, ethyl alcohol, butyl acetate, acetone, diethyl ether, chloroform and acetic acid. This feature is said to be unique with this particular instrument.—*Mine Safety Appliances Co., Braddock, Thomas and Mead Sts., Pittsburgh 8, Pa.*

Ear Inserts Muffle Loud Noise

Improvements in the Sonic Ear-Valve have made it softer and more comfortable to wear. Basis for the improvements is a new silicone-rubber tip that will endure extremes of heat and cold and is more resistant to skin oils and ear wax.

This ear insert contains a tiny sonic filter which acts as a protective ear drum. The harmful effect of loud noises is nullified, but ordinary voice level sounds still can be heard.—*Sigma Engineering Co., 1491 North Vine St., Los Angeles 28, Calif.*

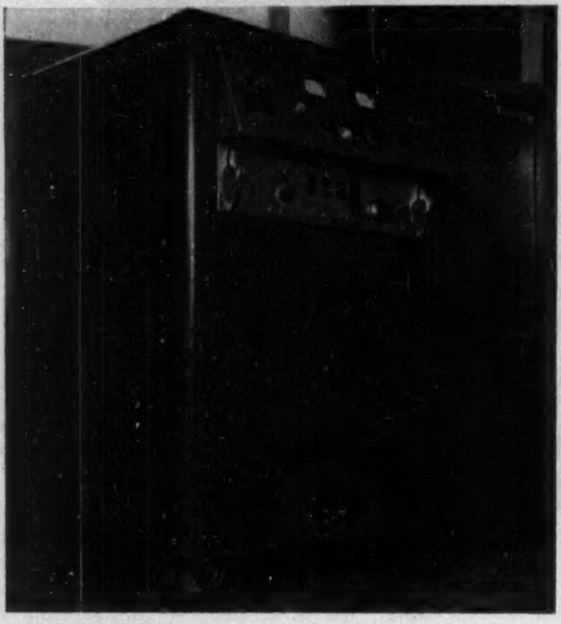
Ultra Violet Lamps Are Explosion-Proof

To meet the need for an explosion-proof air sterilization source, a new ultra violet lamp has been developed for use in antibiotic production. This lamp consists of a 1,200-w. quartz mercury arc with Vycor jacket to eliminate the generation of ozone. The effectiveness of this lamp is said to be eight times that of an ordinary 30-in. germicidal tube.—*Hanovia Chemical & Mfg. Co., 92 Chestnut St., Newark, N. J.*

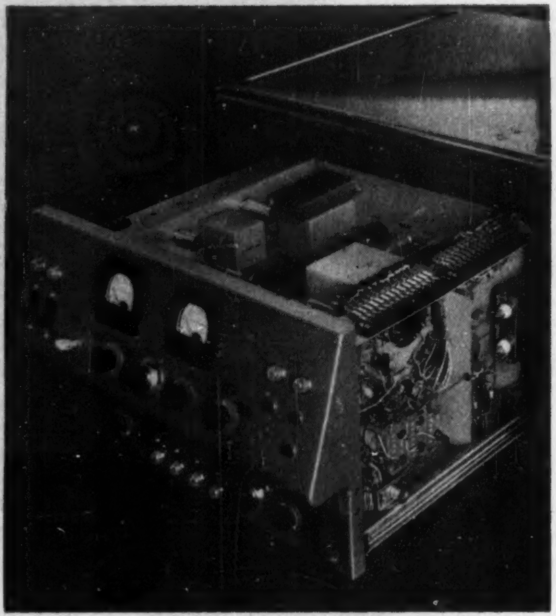
All Leather Gloves Resist High Temperature

All leather heat-resistant gloves able to withstand temperatures up to 800 deg. F. are now being offered. Heat resistance is obtained by impregnating the soft, flexible leather with insulating and refractory materials. Inseam construction guards the threads against undue wear. The inner leather lining is sewn into the finger tips to prevent separation when the gloves are removed.

Model 113G is suitable for temperatures up to 500 deg. F. A reinforced pre-shrunk palm features Model 213G for temperatures up to 800 deg. F.—*Mine Safety Appliances Co., Braddock, Thomas & Meade Sts., Pittsburgh 8, Pa.*



COMPACT UNIT mounted on casters is fully mobile.



ELECTRONICS CHASSIS pulls out for easy servicing.

Mass Spectrometer Moves into Production Spot

Long a valuable laboratory tool it has been adapted to continuous in-plant use. Portable unit can monitor and control processes, detect gas leaks and analyze gases.

Designed primarly to monitor and control continuous processes in chemical plants and oil refineries the new 21-610 mass spectrometer makes precise, almost immediate measurement of any process gas constituent within its range. Simplicity of design makes it compatible with the most complex manufacturing and processing facilities. Available accessories adapt it for use as a highly sensitive production line leak detector and economical analytical mass spectrometer.

Incorporating features previously found only in laboratory equipment the mobile 21-610 meets the most exacting production and plant demands. Major constituents of a process gas or trace impurities can be monitored with equal ease and accuracy.

Atmospheric pressure sampling of gas streams eliminates complex pressure controlling equipment. Special maintenance features insure continuous operation. Automatic protective devices prevent instrument damage.

Any individual molecular fragment from mass 12 through 40 can be monitored with satisfactory separation between adjacent masses. Where separation is not important the range is extendable to mass 80. An auxiliary program permits periodic scanning of a preselected group of masses. Scanning over the instrument's entire range can be readily performed at the operator's discretion. Hydrogen or helium can be monitored by adding an accessory movable shunt to the analyzer magnet.

A manually operated attenuation control permits reducing sensitivity by discrete factors up to 1,000 to provide exceptionally accurate output indications over a wide dynamic range. Fragment abundances are indicated by an output meter.

Provision is also made for either a chart recorder or other indicating devices. The output signal may be used to actuate servo-operated equipment.

Operation of the mass spectrometer is based on the fact that every substance has a unique arrangement of atoms within the molecules, and that bombardment by an intense electron beam causes fragmentation in a unique manner for each substance.

Separation of molecular fragments or masses for individual identification is achieved electrically by acceleration into a strong magnetic field. Here the different articles travel distinct curved paths. By correct adjustment of the acceleration voltage which alters the trajectory any desired group of articles can be made to strike a collector target.

The collector is connected to highly stable amplifying equipment. The minute electrical signals produced by fragments impinging on the collector are raised to a level suitable for direct indication of fragment abundance on meters and chart recorders, or for operation of servo mechanisms and other control equipment. In graphical form the relative quantities of all fragments formed by a substance constitute its mass spectrum which is an unmistakable positive means of identification.

Since spectra of all pure substances are different, a complex analysis can be performed in minimum time by

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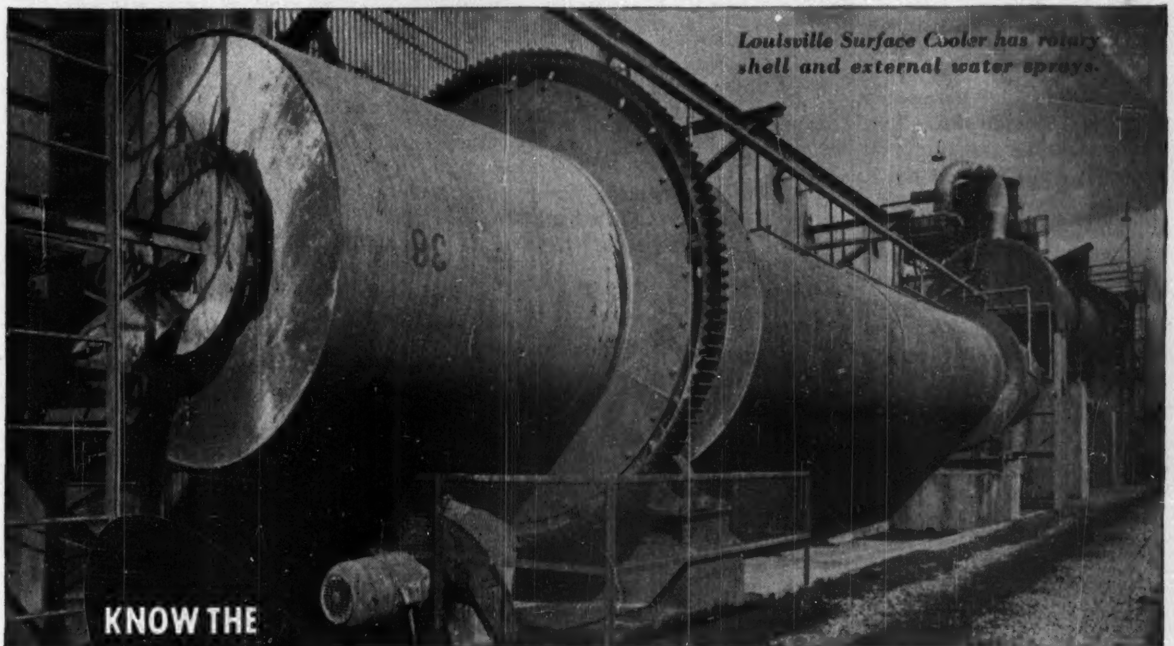

Louisville Surface Cooler has rotary shell and external water sprays.

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algebraically subtracting constituent spectra from the spectrum of an unidentified mixture. In controlling chemical processes adequate indication is often provided by continuously monitoring one representative fragment or mass.

Of particular interest in the construction of the 21-610 portable spectrometer is the unitized arrangement of the electronic, vacuum and structural parts. Pull-out electronic chassis permits easy repair and maintenance without interrupting service. If necessary the entire unit can be quickly removed and replaced. Controls are simplified and centralized on one panel.

All parts on vacuum rack can be quickly disassembled. The Diatron (miniaturized mass spectrometer element) or its filament can be quickly replaced. Vacuum rack can be removed for operation outside of the cabinet if desired.

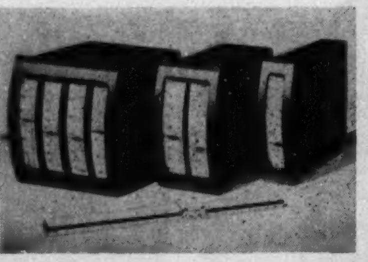
Cost of the basic instrument will be about one-quarter that of the analytical mass spectrometers in use today; with accessories it should run under $10,000.—*Consolidated Engineering Corp., 300 North Sierra Madre Villa, Pasadena, 8, Calif.*

Mercury Vapor Meter Is Highly Sensitive

High sensitivity, light weight and simplified operation are featured in a new meter for measuring mercury vapor concentrations in the atmosphere.

Operation of the instrument is based on the ability of mercury vapor to absorb light of 2,536 A in proportion to its concentration in the air. Light of this wave length is projected across an open space in the instrument to a photocell. Presence of mercury vapor in air passing through the space will alter the amount of light reaching the photocell. Change in light intensity is amplified and indicated by a meter.

Sensitivity of the standard model is 0.005 to 0.1 mg. per cubic meter. A less expensive model covers a range from 0.05 to 10 mg. per cubic meter. Another model features an adjustable alarm which may be set at any desired concentration to warn nearby personnel when a danger exists.—*Harold Kruger Instruments, P. O. Box 164, San Gabriel, Calif.*



Miniature Indicators Have Vertical Scales

Minimum panel mounting space is required for the Mindicator line of miniature vertical scale indicating instruments. These instruments are used as receivers and as direct reading gages and thermometers.

Mindicators designed as receivers for instrument panel boards operate on transmitted pressure of 3 to 15 psig. Measuring elements are individually calibrated metallic bellows.

Direct reading Mindicator thermometers are available in any required scale range from −200 to 1,000 deg. F. Direct reading pressure gages can be furnished in many different scale arrangements from 0-10 psig. to 0-1,000 psig.

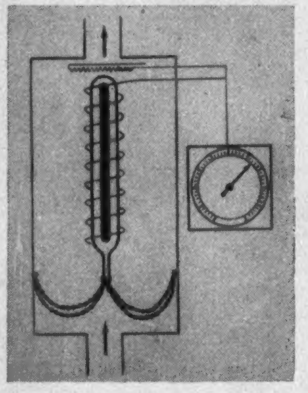
Panel openings for single units are only 5⅜ x 1½ in. Additional width for each unit added to a multiple housing is 1⅜ in.—*The Dickson Co., 7420 Woodlawn Ave., Chicago 19, Ill.*

Pressure Transducer Measures Rapid Surges

Extremely rapid transient pressure surges and high-frequency pressure pulsations can be easily and accurately measured with a new Type 4-301 pressure transducer. The device may also be used for measuring static or slowly varying pressures in both gaseous and liquid systems over an extremely wide temperature range. The transducer's output may be recorded on an oscillograph where extremely rapid pressure changes must be analyzed in relation to time. It may be used also to indicate pressure changes on meters or oscilloscopes which can be monitored visually or photographed.

In operation, a pressurized liquid or gas enters the fluted pressure sensitive cylinder about which are wound the active arms of a four-arm bridge circuit. Even minute pressure variations will change the dimensions of the cylinder which in turn changes the resistance of the wire wound around the cylinder. The resulting bridge unbalanced voltage is proportional to any pressure change and can be fed to either meters, oscilloscopes, or recording devices.

The unit, complete with cable and plug, weighs only 9 oz., and measures 1½ in. in diameter. Initial instruments were designed for 10 psig. operation, but later models will be available with full-scale ranges to 5,000 psig. Materials of construction will be suited to process requirements.—*Consolidated Engineering Corp., 300 North Sierra Madre Villa, Pasadena 8, Calif.*

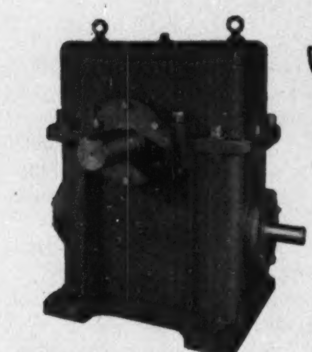


Submerged Plummet Controls Liquid Density

Density of flowing liquids can be continuously indicated, recorded or controlled by the Densitrol instrument. Different models of the instrument provide either direct sight reading, continuous indication or recording, or continuous control. Units have been proven out on operations, such as makeup of mercerizing caustics and brine solutions, mixing of rayon spin bath acids, recovery of acetone, blending or concentrating sugar syrups, measurement of concentrated and dilute acids, and analysis of two component solutions or mixtures.

A totally submerged plummet fastened, by chain of known weight, to a fixed reference point serves as a density-sensitive element. For each density within the range of this plummet chain assembly, the plummet assumes a definite equilibrium position. Any changes in plummet position are translated through plummet core and electrical measuring device into indication, record or control of liquid density.

Plummet action is entirely without



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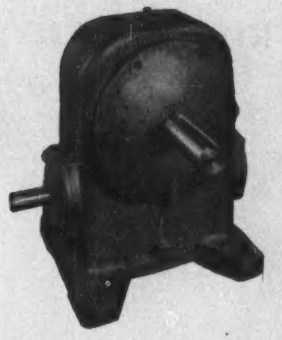

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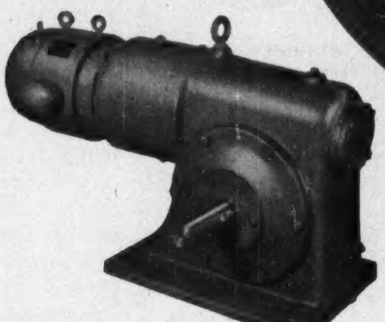
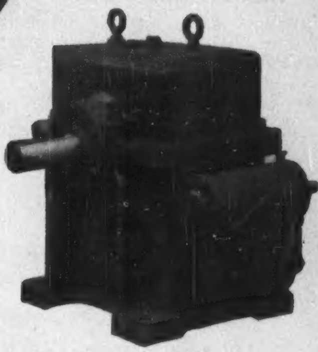


DOUBLE •
Horizontal or Vertical Drive—Each drive type available in 13 sizes, ratio range of 130:1 to 10000 and from .004 to 59.7 horsepower. Vertical drive slow speed shaft extends either upward or downward.



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Generated on tangential feed hobbing machines by tapered and ground hobs. Made from 1" to 100" in diameter and from 24 DP to 1 DP.

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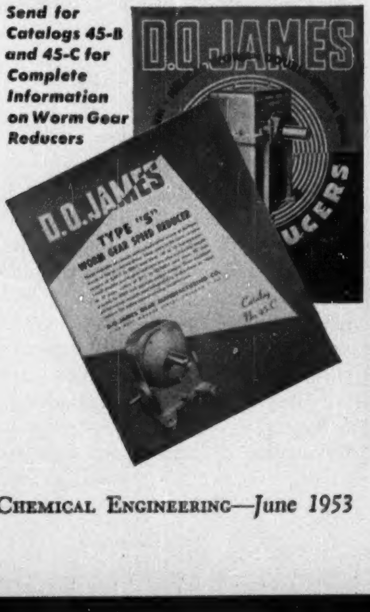

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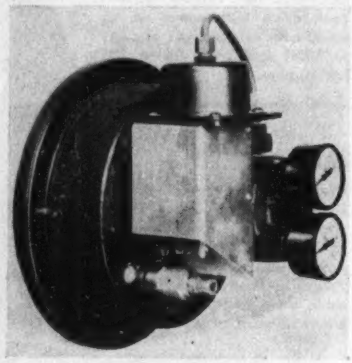
friction and is not affected by vibration. Calibrations can be furnished over a wide range of any selected density. Accuracy for all ranges is plus or minus 3 percent of range or 0.0002 density, whichever is greatest. Sensitivity for all ranges is plus or minus 0.5 percent of range.

Constructions are offered for operating temperatures up to 350 deg. C. and pressures to 600 psi.—*Precision Thermometer & Instrument Co., Dept. 7, 1434 Brandywine St., Philadelphia 30, Pa.*



Pneumatic Instrument Measures Pressures

A new combination pressure gage and pneumatic transmitter covers a range from vacuum to 10,000 psig. Output pressure of the transmitter varies from 3 to 15 lb. (or 5 to 25 lb. as specified) regardless of the range of pressure being measured. Readings can be transmitted up to 1,000 ft. from point of measurement.

Either full-size recording receivers or miniature indicating instruments can be used with the unit. The transmitting instrument is extremely compact, taking no more panel space than the gage itself. Gages are available in either 6 or 8½-in. size.—*Penn Industrial Instrument Corp., 4110 Haverford Ave., Philadelphia 4, Pa.*

Infrared Energy Meter Responds Rapidly

Radiant energy intensities up to 10 w. per sq. in. can be measured with the Type DW-69 infrared meter. Responding in a few seconds, this instrument measures the intensity of high range radiant energy sources. It is also used for studies of infrared radiation effects concerning absorption and transmission quantities of materials.

Typical applications include the determination of drying-lamp field dis-

tribution and experimental studies on paint-baking ovens.

Radiation is measured by a sensitive thermocouple. Accuracy is plus or minus 5 percent of full scale value over a response range of 300 to 3,500 millimicrons.—*General Electric Co., Meter & Instrument Dept., Schenectady 5, N. Y.*

Automatic Switch Protects Vacuum Systems

The safety of equipment depending on a suction delivered lubricant, fuel, water, or similar liquid can now be protected by an automatic vacuum switch. When suction falls below a predetermined negative pressure, the switch automatically cuts off motor or gas engine driving the equipment.

The switch can also serve as a warning control where operating conditions depend on a vacuum such as found in the vacuum firing of ceramics.

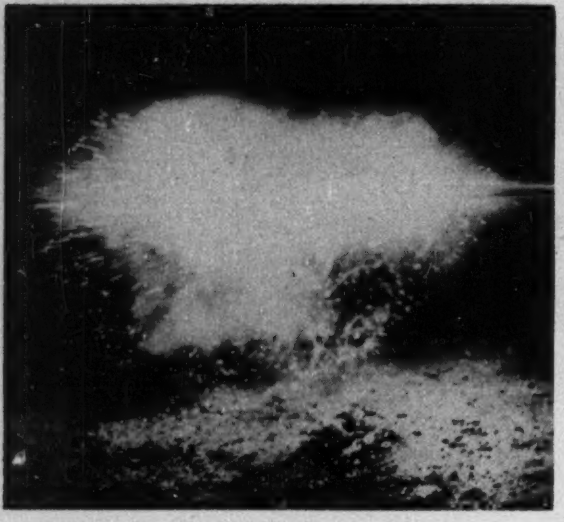
Operating on a spring-loaded rubber diaphragm principle, the Vac-On vacuum switch has silver contact points for heavy duty service. The model for motor use will operate on electric motors up to 2 hp. a.c. or ½ hp. d.c. The gas engine model is designed to short out the spark plug in event of liquid supply failure.—*Jaycon Associates, 404 North Washington Ave., Minneapolis, Minn.*

Wet film thickness gage gives precise direct reading. Unit is approximate size of pocket watch.—*Gardner Laboratory, Inc., Bethesda 14, Md.*

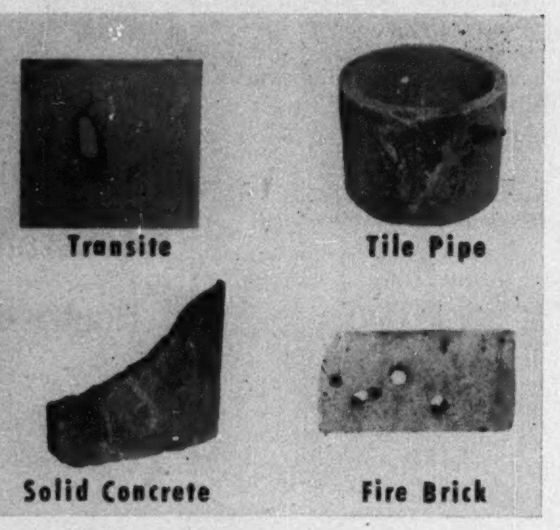
Low-temperature impact tester meets the recommended commercial standard for general purpose vinyl plastic film TS-5165.—*United States Testing Co., Inc., 1415 Park Ave., Hoboken, N. J.*

Automatic electronic pyrometer controller is suitable for two-position control action on batch processes. Twelve standard scale ranges are available for temperatures from 0 to 3,000 deg. F.—*Thermo Electric Co., Inc., Fairlawn, N. J.*

Pyrometer controllers feature an electronic control system based on the frequency modulation principle, a newly developed millivoltmeter mechanism and unit plug-in construction. Selection of temperature ranges varies from 0-400 deg. F. to 0-3,000 deg. F.—*The Bristol Co., Waterbury 20, Conn.*



TORCH-LIKE flame from welding rod in mid-air . . .



CUTS THROUGH many types of non-conductive materials.

Welding Rod Pierces Stone

New rod produces arc without being struck upon metal or connected to ground. Non-conductive stone, concrete and refractories are readily cut or pierced.

An electric arc resembling a super torch flame 5 to 8 in. long can now be produced in mid air. Heat generation over 8,000 deg. F. is obtained.

No ground connection to the base material is needed. This opens up many possibilities for cutting and piercing non-conductive materials.

With the Dyn Arc process it is possible to prepare holes in concrete for installation of machinery in a matter of seconds. Pipes buried in solid masonry can be exposed with ease. Wall sections can be removed as readily as a conventional arc welder cuts metal. This eliminates laborious drilling, chipping or breaking of stone, concrete or refractory materials.

Secret of the Dyne Arc process lies in the Dyna Trode self-energizing arc rod. Two metallic welding rods encased within a special heavy coating comprise the Dyna Trode. Arcing takes place between the outer tips of the two rods.

Rod coating is formulated to give the thermo chemical inter-reaction with the arc stream needed to give effective operation. While the current is arcing the coating is consumed more slowly than the core. This forms a crucible or a tube of coating which concentrates the arc energy into a fine tip. Thermal ionization of the coating by the arc stream, together with the energy concentration produces the conditions necessary for piercing and melting refractory or other non-conductive material.

Dyna Trode arc rod is held in a special Dyna Trode holder. It is said this holder can be used with conventional welding electrodes as well.

Arc rod and holder are the only special pieces of equipment required. Any conventional d.c. welding machine of 200 amps or more capacity is satisfactory. To start the arc the operator merely switches on the current. Arcing is continuous independent of external electric conductivity normally associated with electric arc welding. This independence of action makes an operation such as wire cutting an easy continuous one.

Penetration through refractory material varies from one to three inches per minute according to the nature of the material being pierced. Individual Dyna Trode rods have a life of approximately 55 sec. This means that this time interval is required to consume the entire rod.—*Chemotec Div., Eutectic Welding Alloys Corp., 40-40-172 St., Flushing, N. Y.*

Speed of Heavy-Duty Drive Can Be Varied

A new line of double-reduction, variable-speed electric drives answers a growing demand for rugged, self-contained heavy-duty units providing infinite variable speeds in low ranges. These 20- and 25-hp. units are available with speed variations of 2 to 1, 3 to 1, and 4 to 1. The 20 hp. Type 364 KFEB is available with maximum speeds ranging from 176 to 42 rpm. In the 25-hp Type 365 KFEB drive maximum speeds range from 176 to 64 rpm.

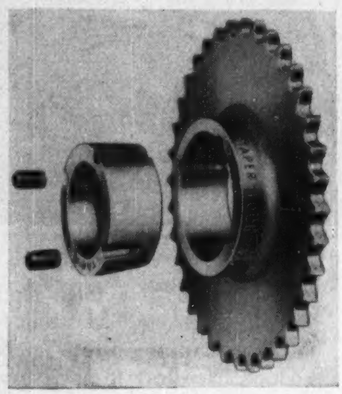
Efficient power transmission and constant selected speed are assured by positively adjusted variable-pitch pulleys. Drip-proof and splash-proof models feature direct-through ventilation. A dual cooling system on the totally enclosed fan-cooled model gives both internal and external cooling.—*Sterling Electric Motors, Inc., 5401 Anaheim-Telegraph Rd., Los Angeles 22, Calif.*

Overload Relay Has Dual Features

Type C Silic-O-Netic overload relay combines extremely high-speed operations with time delay for starting inrush. The unit can be furnished with time delay curves to match the

characteristics of the protected equipment at overloads in excess of eight times the rating. Response is instantaneous for protection of hermetically sealed motors, electronic circuits and control systems.

A hermetically sealed brass tube extends through and beyond the solenoid coil. This tube holds a small movable iron core surrounded by silicone fluid. On starting inrush or small overloads, the magnetic force is not sufficient to attract the armature. It does, however, draw the iron core into the field at a rate controlled by the silicone viscosity. When the core reaches the pole piece, the relay responds providing the necessary time delay. On large overloads the core is not a factor in relay operation which is instantaneous.—*Heinemann Electric Co., 357 Plum St., Trenton 2, N. J.*

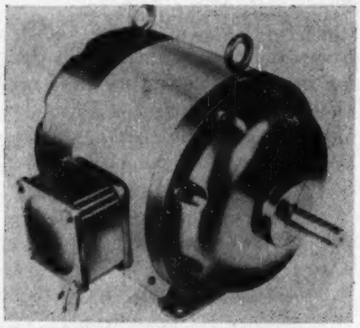


New Line Of Chain Drives

Distributors' shelves are now stocked with a new line of Taper-Lock sprockets and roller chains. These items mark the entry of a 75-year-old power transmission firm into the field of roller chain drives. Big advantage claimed is that the Taper-Lock principle brings a new off-the-shelf availability to roller chain drives.

Taper-Lock sprockets can be fitted simply to any shaft size merely by using the correct size of Taper-Lock bushing. Costly and time consuming reboring of sprockets to fit shafts is eliminated.

Distributor stocks cover a complete range of B-type steel sprockets, 40 to 100 pitch. Chain will be packaged in 10 ft. lengths and can be furnished in 50 and 100 ft. reels.—*Dodge Mfg. Corp., Mishawaka, Ind.*

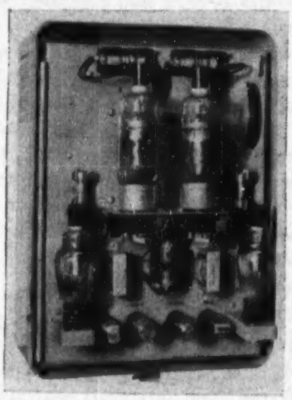


New Line of Chemical Plant Motors

Production has been started on a new line of chemical plant motors in ratings from one to 40 hp., in NEMA frames up to 405. The new motors will be available in totally enclosed and Underwriters' Approved explosion-proof construction.

Special class A chemical insulation treatments permit use of the new motors in applications involving acids, alkalis, dying and bleaching, canning and packing, and peroxide. Attention is also given to protection of metal parts from corrosion.

A wide variety of construction modifications is available including a choice of construction materials.—*Robbins & Myers, Inc., Springfield 99, Ohio.*

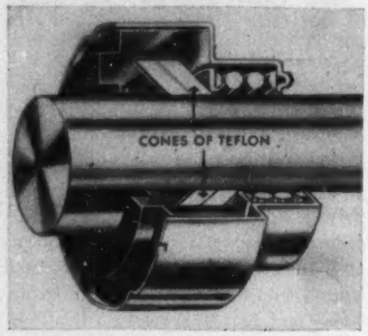


Electronic Drive Simplified for Lower Cost

Simplification and lower cost characterize a recent addition to the line of Thy-mo-trol packaged electronic adjustable-speed drives. Although not including some of the refinements of the precision-type models this smaller (¾ to 3 hp.) model gives smooth stepless speed control, pre-set speed control and holds speed independent of ordinary load changes.

Offered in the new model are standard speed ranges of 5 to 1 and 20 to 1. Either reversing or non-reversing

forms can be furnished. Dynamic braking and standard overload and undervoltage protection are included. Operation is on either 220 or 440 v., 50 or 60 cycle.—*General Electric Co., Schenectady 5, N. Y.*



All Purpose Shaft Seal Gives Long Service Life

Long service life is claimed for a new all-purpose rotary shaft mechanical seal. Special bevelled cones of Teflon (DuPont trademark for tetrafluoroethylene resin) are utilized as the flexible member. This adapts the seal for services involving water, oil, corrosives or acids; temperatures from −100 to 450 deg. F.; vacuums and pressures to 200 psi.; and high shaft speeds.

Seal is available for shaft diameters of 1/4, 3/8, 1/2, 5/8 and 3/4 in. Metal components of the seal can be specified to meet service requirements.—*The Crane Packing Co., Dept. C-12, 1800 West Cuyler Ave., Chicago 13, Ill.*

Mechanical Shaft Seal Built For Heavy Duty

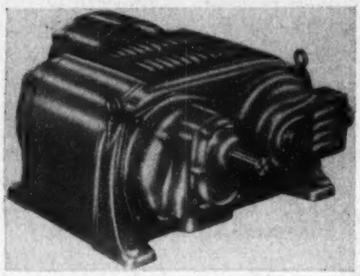
Ability to withstand high pressures up to 1,000 psi. has been designed into a new heavy duty mechanical shaft seal. Furnished as a packaged unit the type 8-B shaft seal is preassembled on a sleeve for ready installation. Extremely compact design adapts it for use in conventional pump stuffing boxes. On split case pumps it is not necessary to lift the upper half of the casing to install or remove the seal.

A rotating sealing washer and a floating stationary seat are incorporated in the unit. Balance is accomplished by lowering the washer face to a point where stuffing box pressure is not exerted against the sealing area.

Rotating assembly consists of a re-

tainer positively driven by the sleeve, with the washer driven from dents in the retainer. Assembly is held in contact with the lapped face of the seat by means of multiple springs spaced around the sleeve at the back of the retainer.

Sealing between sleeve and shaft and also between washer and sleeve is provided by O-rings. This affords sufficient flexibility in the rotating assembly to compensate for axial and radial shaft movement and for normal wear of sealing faces. Another O-ring is used between the stationary seat and end plate as a cushion to prevent stresses on the highly lapped face.—*The Crane Packing Co., Dept. C-12, 1800 West Cuyler Ave., Chicago 13, Ill.*



Variable Speed Drive Has New Flat Assembly

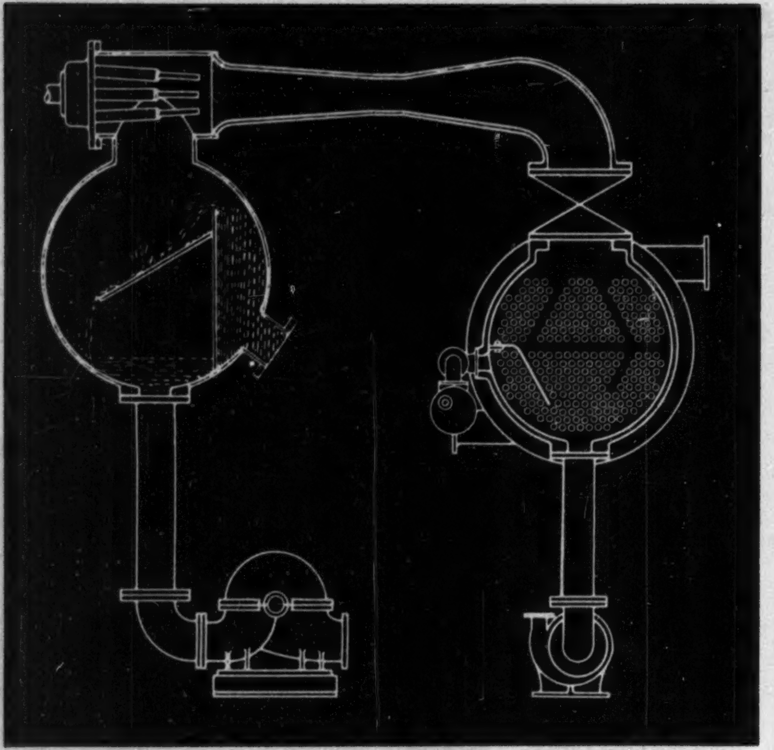
Addition of a new horizontal frame size makes Varidrive motors now available in horizontal assembly up to the 30 hp. size. This makes possible a more compact installation for applications demanding a horizontal set-up.

Features included in the 64 VE drive are identical with those found in upright models. These are all-in-one construction, microspeed control and indicator, splined sheaves, double cog belts with tension control for permanent belt adjustment, dual belt construction, asbestos-protected motor and normalized castings.—*U. S. Electrical Motors Inc., Box 2058, Terminal Annex, Los Angeles 54, Calif.*

Storage Battery Capacity Boosted Twenty Percent

Use of new materials together with structural changes gives the new line of T-H Exide iron clad batteries 20 percent more capacity. In modern practice this increased capacity is needed in many materials handling and haulage jobs to work through a full shift.

One important change which was made is the use of polyethylene non-oxidizing slotted plastic tubes to hold



the active material in the positive plate. A polyethylene acid proof tube sealer on the bottom of the positive plate seals in the active material and maintains high battery capacity for a longer working life. Grids contain corrosion resistant Silvium which also contributes toward longer battery life. Positive plates are larger and balanced by extra heavy negative plates.—*The Electric Storage Battery Co., 19th St. and Allegheny Ave., Philadelphia, Pa.*

Riveted roller chain incorporates single pin couplers spaced so any length can be made up without cutting rivets or damaging parts. Chains are boxed in 10-ft. sections.—*Baldwin-Duckworth, Div. of Chain Belt Co., Springfield 2, Mass.*

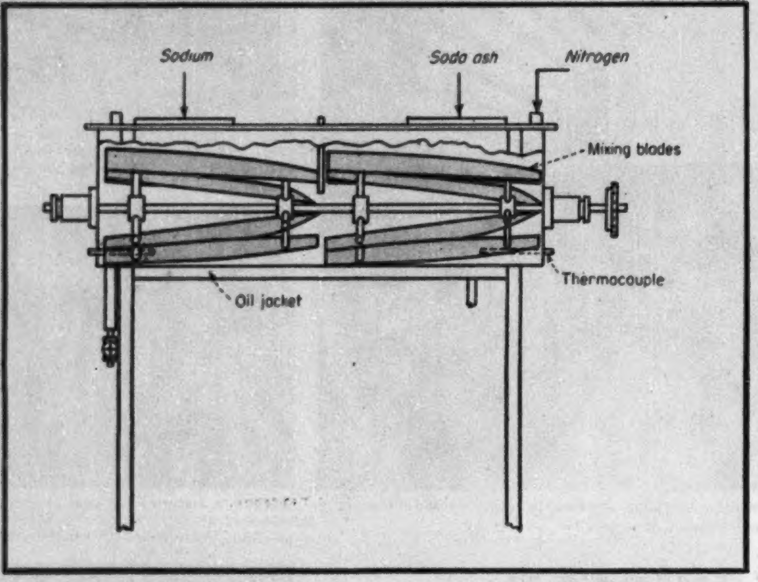
Overload release clutch gives instantaneous trigger action. Clutch installs easily on sprocket chain belt and gear drives.—*Overload Release Clutch Co., Inc., Dept. E, 1162 Stuyvesant Ave., Irvington, N. J.*

New contact water brake is designed to absorb power loads as high as 1,000 hp. Standard units weigh from 35 to 65 lb., with over-all dimensions being within 14x10 in. Unit is said to be ideal for running power tests.—*Industrial Engineering Co., Island Rd. & Suffolk St., Philadelphia 42, Pa.*

Storage cabinet for maintenance department has 128 drawers. Cabinets are all-steel welded construction with plastic drawers for easy identification of contents.—*Akro-Mils, Inc., P. O. Box 989, Akron 9, Ohio.*

New motor-operated field rheostat is used to adjust d.c. motor speed on units up to 200 hp. and generator voltage up to 300 kw. Units are designed for ease of installation and maintenance.—*Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa.*

Chain breaking tool can be used to disconnect any roller chain from ¼ to ¾-in. pitch. Tool jaws are pearlitic heat-treated malleable iron. Pressing tip is case-hardened tool steel. Tool length is 5½ in.—*Boston Gear Works, 14 Hayward St., Quincy 71, Mass.*



Pilot plant equipment can coat 20 lb. of soda ash with 10 percent sodium film. Preparation takes place under inert nitrogen atmosphere.

Sodium Wears a New Harness

You can use a simple new method to coat inert carriers with sodium. This more reactive, easier-to-control form should widen the metal's application potential.

Large surface area, short reaction times and close temperature control are rewards promised by USI to users of a new form of sodium. Company researchers are prepared to tell you how to claim these rewards by spreading atomic layers of sodium over inert solids of high surface area.

The product, which they call "high surface sodium" (HSS) enhances the value of metallic sodium for preparation of finely divided metals (eg., reduction of titanium tetrachloride), for purification of hydrocarbons and ethers and for the preparation of inorganic and organic sodium derivatives. HSS is said to provide:

- Easy control of reaction rates and temperatures above and below the melting point of sodium.
- Simple adaptation to continuous operations.
- Dry-way reactions of sodium.
- Greater safety by eliminating flammable solvents.
- High yields.
- Preparation of products in finely divided and reactive states.
- Means of avoiding induction periods.

USI believes that its method of preparation is simple and economical enough for buyers of sodium to make the product at the point of use. Molten sodium is mixed with such inert solid materials as salt, sodium carbonate, carbon, metal powders or ceramic materials. Usually, sodium spontaneously spreads over the surface of hot dry solids at temperatures between 100 and 200 deg. C. To obtain maximum efficiency and to protect the reactivity of HSS it is necessary to carry out its preparation and subsequent use under an inert atmosphere. Likewise it is desirable, whenever possible, to prepare and use HSS in the same reaction vessel.

These sodium-coated solids remain free flowing over a wide temperature range in mixtures containing as much as 30 percent sodium. The tremendous surface area is said to present sodium at its maximum energy level in an easily handled, easily controlled form. USI feels that this form may provide the key to solution of many industrial chemical problems. Those which the company's research staff has worked on include: (1) removal of last traces of sulfur from gasoline, special white oils and other naphthas requiring extremely low sulfur levels; (2) preparation of colloidal metals for use as catalysts or as intermediates in preparation of certain metal derivatives; (3) preparation in situ of sodium derivatives such as sodium hydride or sodamide for use in subsequent reactions; (4) catalytic applications where the extremely finely divided sodium should have definite advantages; (5) preparation of organosodium derivatives where highly reactive sodium is needed and it is desirable to avoid the use of solvents.

The most attractive features of the HSS procedure for producing finely divided metals are the simple technique involved and the low reaction temperature. Satisfactory reaction rates and yields are obtained at 125 to 250 deg. C.

Examples of metal compounds which have been reduced in HSS systems include nickel chloride, copper chloride, lead chloride, chloroplatinic acid, silicon tetrachloride, titanium tetrachloride. It is recommended whenever possible to use the reduction product itself as the sodium carrier in a continuous or semi-continuous process. Thus, part of the reaction mixture is recycled to prepare more HSS which, in turn, is reacted with more of the metal salt.

In refining operations, USI researchers state that HSS may be used in fixed and moving solids systems to effect thorough refining at operating temperatures above and below the melting point of sodium. They report that the reduction of sulfur in certain petroleum naphthas to less than 0.001 percent, and the improvement in the odor to a degree which exceeds primary odor standards can be achieved easily.

USI, which sells metallic sodium in

quantities ranging from 1-lb. blocks to tank cars, offers detailed technical assistance in preparing HSS in specific laboratory or plant applications.

HSS, like the older sodium dispersions, should provide a new avenue toward expanding the 300-million-pound-per-year market for sodium. And it should be a help to sodium producers in proving their thesis that sodium is no more difficult to work with than many other less-maligned industrial chemicals consumed in large quantities every day—*U. S. Industrial Chemicals Co., 120 Broadway, New York 5, N. Y.*

IN BRIEF—A capsulated listing of this month's newsworthy products

Unsaturated Glycol

Reactive chemical intermediate derived from acetylene.

An unsaturated glycol, butene-1, 4-diol, is now available in limited quantities from General Aniline & Film Corporation's development program on high pressure acetylene derivatives.

Butenediol is a reactive chemical intermediate which cyclizes to dihydrofuran, hydroxylates to erythritol, and forms a variety of unsaturated polyesters and alkyds. It also reacts with dibasic acids to form plasticizers and takes part in many other reactions typical of compounds with the hydroxyl groups and the carbon-carbon double bond.—*Commercial Development Dept., General Aniline & Film Corp., 435 Hudson St., New York 14, N. Y.*

Acrylic Dispersion

For emulsion paint vehicles of superior color and color retention, scrub resistance after overnight dry.

A new 100 percent acrylic dispersion in water is said to give emulsion paint formulations many properties which formerly had to be built in with a variety of additives. The new Rhoplex AC-33 alone can usually be counted on to build up body, prevent putrefaction, mask odor, stabilize viscosity, impart adequate toughness, protect against freezing and thawing.

Like its brother acrylic plastics, the compound boasts excellent color retention, permanence and chemical resistance. According to the manufacturer, coatings made with the vehicle offer excellent scrub resistance after only an overnight dry.

Supplied as a 46 percent solids dispersion in water, its specific gravity is 1.04, pH 9.0 to 9.5. The resin itself is fully polymerized; its films dry solely by evaporation of water.—*Rohm & Haas Co., 235 South 8th St., Philadelphia 5, Pa.*

Methyl Toluenesulfonate

Good stability recommends it to dyestuff makers as a methylating agent.

Methyl toluenesulfonate, a methylating agent in dyestuff manufacture, is available for the first time in commercial quantities.

The product, a methyl ester of a high ortho-low para mixture of toluenesulfonic acid, is said to be more stable than methyl paratoluenesulfonate for which it is a replacement.

It also has been suggested as a catalyst in the preparation of alkyd resins and other organic esters, and in the manufacture of photographic chemicals and pharmaceutical intermediates.—*Monsanto Chemical Co., St. Louis 4, Mo.*

Silicone Varnish

Slashes time required for varnishing Class H insulation.

A silicone dipping and impregnating varnish for Class H insulation has been developed by Dow Corning. Claims for its superiority lie on the fact that it cures as rapidly as typical Class B varnishes and yet has over 100 times their dielectric life at 200 deg. C.

Key to the short curing time is the fact that the compound, called Dow Corning 997 Varnish, shows even less tendency to bubble at 300 deg. F. than many of the better organic varnishes. The elimination of graduated curing schedules reduces total processing time to less than a quarter of the time formerly required for Class H equipment.

The increased dielectric life of this new resin is indicated by the measurement of dielectric strength after aging at 250 deg. C. Dow Corning 997 retained over 50 percent of its original dielectric strength after 4,500 hours, as compared to 2,000 hr. for Dow Corning 996 and only 60 hr. for conventional Class B varnishes.—*Dow Corning Corp., Midland, Mich.*

Bromine Carrier

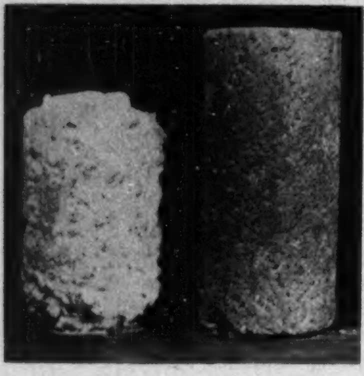
Low cost and ability to release controlled amounts of bromine give it bright prospects in organic syntheses.

A new brominating and oxidizing agent is now being produced in commercial quantities. It is BROM 55 (Dibromo Dimethyl Hydantoin), which because of its low cost, is expected to replace other bromine carriers and make its use practical in certain applications now using liquid bromine.

BROM 55 is a crystaline powder, containing 55 percent bromine combined with an organic carrier. The bromine can be released under strict control to achieve a desired reaction and minimize side reactions, thereby increasing yields in many organic syntheses.

Among other advantages, BROM 55 is safe to handle and ship. Refrigeration while in storage is unneces-

sary. It is shipped in ordinary fiber drums, with no costly containers or recovered carrier to be returned to the manufacturer.—*McKesson & Robbins, Chemical Dept., 155 East 44th St., New York 17, N. Y.*



Asphaltic Waterproofing Material

After 24-hr. immersion in saturated sodium sulfate, treated concrete, right, remains intact.

Tests on a new asphaltic waterproofing material have shown its moisture-absorption rate to be only 1.09. Of eight other waterproofing materials tested, the lowest rate of absorption by capillary action was 7.8 percent.

Moreover, the tests disclosed that this asphaltic product, called Hydropel, accomplished this degree of waterproofing without loss of strength or resistance to abrasion.

In appearance the product is a brown, slightly viscous liquid. Chemically, it is an aqueous suspension of colloidal asphalt developed as an integral waterproofing admix in cement concrete and mortars. It may be readily poured or transferred with open impeller-type centrifugal pumps. The material is miscible with water; consequently concrete mixing equipment may be washed out with water.—*American Bitumuls & Asphalt Co., San Francisco, Calif.*

Rubber-Base Coating

For floors, walls and equipment in chemical process industries plants.

Durable lasting finishes for floors, walls, structural steel, tanks, ducts and process equipment are said to come of using a new chemical and corrosion resistant rubber base coating. The coating is formulated with a heat-stable thermoplastic resin obtained by the copolymerization of styrene and butadiene.

It is said to have excellent adhesion to all clean, dry surfaces and to give good results with minimum surface preparation. No primer is needed. Two coats provide excellent protection against fumes, vapors and occasional spillage of acids and alkalies.

It is not affected by fats, oils or greases. It has excellent di-electric properties and provides electrical insulation over a wide frequency range. It is extremely heat resistant—up to 250° F. continuous, and even higher for short periods of time.

This coating is non-oxidizing and non-saponifiable. Ordinary paints in the presence of moisture and free alkali are converted to soaps and soon destroyed. Where unusually high alkali resistance is a requirement Pliogard produces films of excellent durability.—*Saran Protective Coatings Co., 2415 Burdette Ave., Ferndale 20, Mich.*

Silicone Dioxide

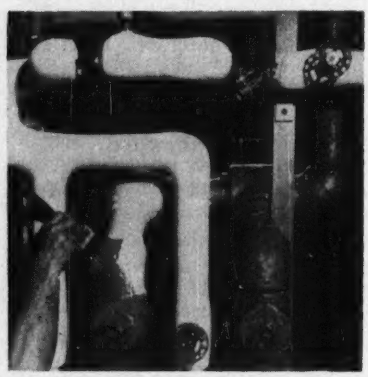
A white "carbon black" for rubber-industry compounders.

A 99 percent pure silicon dioxide powder called Aerosil has just become commercially available in this country. It is said that the powder is the nearest approach to a white "carbon black" for the manufacture of white and colored rubber products possessing the strength and toughness associated with carbon black-reinforced rubber.

In manufacturing the product, called Aerosil, the silica particles are almost instantaneously formed in a high temperature gaseous environment. The collection of Aerosil particles from the gaseous phase results in a product of extremely low bulk density, a property which permits easy dispersion because of the high degree of particle separation. High purity, small particle size, enormous surface area, and easy dispersion contribute to Aerosil's usefulness and versatility.

Aerosil is reportedly effective as a thickening and gelling agent in all types of fluids. This property is of great interest in the lubrications, plastics, paint, varnish, printing ink, and cosmetic industries. In the paint, varnish and printing ink industries Aerosil also functions as an emulsion stabilizer, pigment stabilizing agent, and flatting agent. It can be used as an anti-caking agent to improve the free-flowing properties of various powdered materials. Water dispersions of the powder are easily prepared for use in emulsion paint, paper, latex, and other applications requiring aqueous systems. A number of applications in the insecticide, adhesive, floor wax, and electrical industries have been reported.

Aerosil is a product developed by the well-known German chemical company, Degussa (Deutsche-Gold-und Silber-Scheideanstalt Vormals Roessler), located in Frankfurt. Godfrey L. Cabot, Inc., the world's largest producer of carbon black, has arranged with Degussa a research and patent licensing agreement as an outgrowth of mutual research interests in the field of silica and other inorganic oxide pigments. At the outset, Cabot will import commercial quantities of Aerosil for sale by Cabot in this country. It is expected that a sufficient market will be established for production facilities to be built in the United States.—*Godfrey L. Cabot, Inc., 77 Franklin St., Boston 10, Mass.*



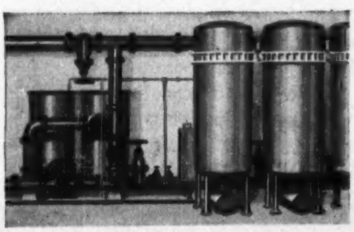
Plastic Insulation

New finish combines color identification and insulation for refrigerant, cold water, steam and other lines.

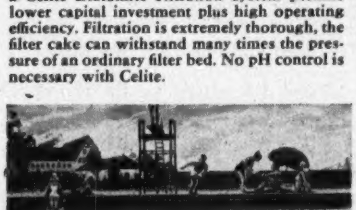
A tough new plastic coating is said to withstand temperatures to 160 deg. F. without cracking, shrinking or crazing. Called Insulcolor, it is meant

CELITE FILTRATION produces clear sparkling water

. . . even removes chlorine-resistant organisms



In municipal water works—engineers find that a Celite Diatomite Filtration System permits lower capital investment plus high operating efficiency. Filtration is extremely thorough, the filter cake can withstand many times the pressure of an ordinary filter bed. No pH control is necessary with Celite.



In swimming pools—operators find that Celite Filtration not only safeguards the purity of pool water, but it provides sparkling clear, inviting water—an important asset in attracting customers. With Celite Filtration, there is a continuous recycling of water at fast flow rates, and the need for chemical treatment is reduced.

Celite* Filtration removes even the finest suspended solids such as amoebae and algae—many of which cannot be filtered by other means. All these impurities are entrapped by Celite's almost infinite network of tiny porous particles . . . thus reducing the need for chemical treatment. Celite offers many other advantages, too . . . it permits important space savings in the installation, high flow rates are maintained, and far less backwash water is required for cleaning the system.

Carefully processed from the purest deposits of diatomaceous earth, Celite is available in nine standard grades. Each is designed to filter out suspended impurities of specific size and type. Utmost uniformity of product is maintained, so that whenever you reorder, you are assured of the same accurately graded powder.

Municipal water works engineers, food processors, beverage manufacturers, swimming pool operators . . . all who require "drinking-pure" water, can benefit from filtration with Celite Filter Aids. It will pay you to investigate the many advantages of Celite for your particular requirement! To have a Celite Filtration Engineer study your problem and offer recommendations, simply write Johns-Manville, Box 60, New York 16, New York. In Canada, 199 Bay Street, Toronto 1, Ontario. No obligation or cost.

*T.M. Reg. U. S. Pat. Off.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville CELITE FILTER AIDS

PRODUCT NEWS, *cont. . .*

for use over heat insulations, cork pipe covering and lagging as well as over cork-insulated air conditioning ducts.

Available in white and six colors, Insulcolor furnishes finishes notable for resistance to abrasion and water. Applied by either brush or spray, they are recommended for both indoors and outdoors.

No inflammable solvents are used in Insulcolor so that, when dry, it is classified as a fire-retardant.—*Armstrong Cork Co., Lancaster, Pa.*

Lubricant

Ultra-high resistance to breakdown claimed for lithium base grease.

Lithium 12-hydroxy stearate accounts for unique multi-purpose properties in Shell's new Alvania Grease. These properties are said to include:

1. Mechanical stability—the grease will withstand over a million strokes in an ASTM motorized worker test without loss of body.
2. High water tolerance—it has been known to maintain peak consistency and lubricating qualities with as much as 32.5 percent water present.
3. Broad temperature range—it achieves high pumpability (for automatic grease systems) and movement at low temperatures and undergoes no phase change as temperature rises to the high melting point.
5. Low rate of oxidation.
6. Long induction period.
7. Excellent storage stability.—*Shell Oil Co., 50 West 50th St., New York 20, N. Y.*

Hard Rubber

New synthetic excels in rigidity, heat and chemical resistance.

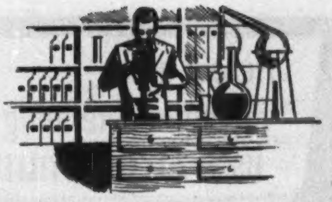
Based on nitrile synthetic rubber (Buna-N), a new compound called Ace Tempron has been developed for sustained high-temperature applications in handling many corrosive solutions. In chemical resistance at elevated temperatures, Tempron generally excels other rubber and plastic materials.

At room temperature, it resists nearly as many inorganic corrosives as natural hard rubber, and in addition, it is resistant to many organic chemicals which attack natural hard rubber,

4 reasons why you should specify ACETONE from CARBIDE AND CARBON

. . . Every one is a plus value for you.

1

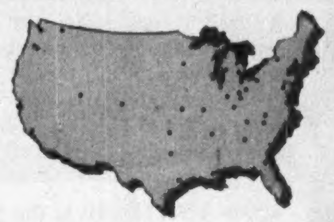


Highest specification material, acetone purity over 99.5%; APHA color less than 10. This uniformity means you can standardize on formulations and processes.

2

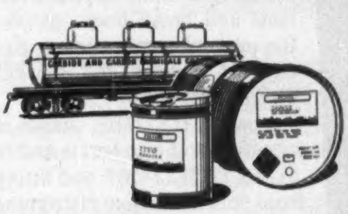
Excellent odor, resulting from high purity, means a more desirable denaturant for alcohol formulas and more saleable consumer products.

3



49 convenient warehouse stocks to serve you with fast deliveries.

4



Available in the quantities best suited to fit your unloading and storage facilities—single drums, drum carloads, compartment tank cars, tank cars, and tank trucks in certain areas.

For further information on acetone, or any of Carbide's chemicals, call or write for your copy of "Physical Properties of Synthetic Organic Chemicals," (F-6136). Offices in 21 principal cities. In Canada: Carbide and Carbon Chemicals, Limited, Toronto.

CARBIDE AND CARBON CHEMICALS

Carbide and Carbon Chemicals Company
A Division of
Union Carbide and Carbon Corporation
30 East 42nd Street New York 17, N. Y.

soft rubber, and plastics. For instance, at room temperature it resists aliphatic hydrocarbons such as hexane, hexene, and other solvents such as ether, benzene, carbon tetrachloride, ethyl acetate, and benzaldehyde. It is resistant to oils. It is not recommended for sodium hypochlorite or for strong oxidizing agents such as nitric acid.

As shown in the table of properties attached, Tempron has high tensile strength, (7,500 psi.), on a par with the better plastics. It's heat distortion temperature is 260-275 deg. F. Excellent di-electric properties suggest applications in electrical parts operating at high temperatures. It also offers an opportunity to save weight.

Tempron is not just one formula. Rather it is a group of compounds which can be altered in many different ways to give just the right combination of physical, chemical and electrical properties for each specific application. At present Tempron is available in four forms: (1) pipe and fittings; (2) molded parts, with limitless design possibilities; (3) sheet, rod and tubes from which a wide variety of shapes can be machined or fabricated; and, (4) a hand-fabricating process for making tanks, large fittings, etc., by forming sheets of Tempron around cores or mandrels while still in the soft state prior to vulcanization.—*American Hard Rubber Co.,* 10 *East* 40*th St., New York* 16, *N. Y.*

An unexpected lubrication property for wet processing has been discovered in Atolene RW, a sulfated ester of oleic acid which was originally marketed as a wetting and dye-levelling agent. Investigation showed that this property was due to the fact that Atolene RW is almost completely sulfated (other sulfated esters of oleic acid on the market are only 50 percent sulfated) which causes absorption of the sulfated ester by the fibers on their surface during dyeing and scouring. This layer of fatty molecules acts as a lubricating film during wet processing.—*Dexter Chemical Corp.,* 819 *Edgewater Rd., New York* 59, *N. Y.*

New finish for synthetic fibers is said to produce a soft, silky hand on viscose, acetate, nylon and others. Cationic in nature, this substantive softener is said to improve the cut-

ting and laying up properties and help to control static electricity.—*Dexter Chemical Corp., 819 Edgewater Rd., New York 59, N. Y.*

Low-temperature lubricants are being made from turpentine via methods under development by the Dept. of Agriculture and Navy chemists. Specifically, the principal component of turpentine, alpha-pinene, is oxidized to the dibasic pinic acid. This, in turn, is esterified with normal alcohols containing from four to ten carbon atoms per molecule to form a series of dialkyl pinates. Tests on several of these pinates appear promising and a blend of mineral oil with synthetics and additives is now in use under Arctic conditions. The principal problem now under investigation is the development of a low-cost method of making pinic acid from alph-pinene.—*Dept. of Defense, Office of Public Information, Washington 25, D. C.*

Powdered asphalt paint called Baromix is now on the market which, when mixed with kerosene, provide a permanent bond to metal, wood, concrete or composition. The asphaltic base makes the paint resistant to weather, smoke, fumes and soil acids.—Berry Asphalt Co., Magnolia, Ark.

A new line of dyestuffs consisting of mixtures of naphthols and stabilized diazos has been made available to the textile industry. Known as Spectrosols, the new dyes are "made up fresh" to specifications at whichever of the manufacturer's plants is nearest to the individual customer. Purpose of this arrangement is to reduce to a minimum the loss of color value due to prolonged storage.—*Hilton-Davis Chemical Co., Cincinnati, Ohio.*

Deuteroparaffin, a target material for use in cyclotrons, is now commercially available for the first time. When bombarded with accelerated deuterons, it becomes a relatively inexpensive neutron source. Available as a pure white powder, the material melts at about 110 to 120 deg. C. and resolidifies to a hard sheet.—*Tracerlab Inc., 130 High St., Boston 10, Mass.* —End

This sample section of a TRANE Brazed Aluminum Heat Exchanger shows how its construction can pack up to 450 sq. ft. of surface into a single cu. ft. of space.

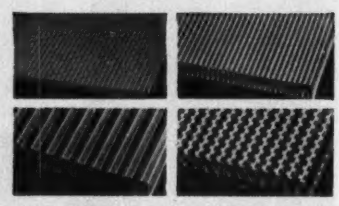
Is this your key to a new product or process?

New TRANE Brazed Aluminum Surface makes NEW products and processes not only possible...but practical. Here's why:

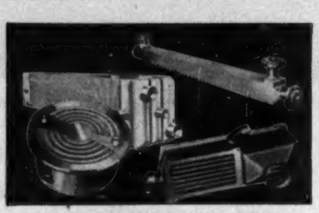
1. Wider range of core sizes and shapes.
2. Greater variety of surfaces.
3. Almost unlimited design flexibility.
4. Up to 9 times more surface for the heat exchange job than with conventional ¾" shell-and-tube construction.
5. Light weight. Yet takes test pressures up to 1,000 lbs. per sq. inch and temperatures from —300° to 500° F.
6. Can handle 5 fluids or more at one time.
7. Can produce more heat transfer in ¼ the space, with ⅙ the weight.

What's your heat transfer problem? Liquid-to-liquid, gas-to-gas, liquid-to-gas? Condensing and vaporizing fluids? You may find a new and better solution in this new kind of all-aluminum heat transfer surface . . . developed by TRANE.

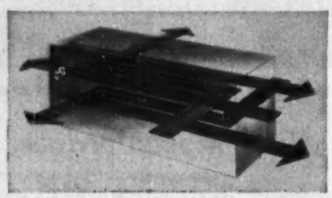
On large or small jobs, TRANE Brazed Aluminum Heat Exchangers can solve almost any heat transfer problem. Multiple-core units can be furnished. You can get temperature approaches of 5° to 10° F.



Select the surface you need. Straight and continuous, serrated, herringbone or perforated. Height, thickness and fin-spacing also can be varied to meet required heat transfer and pressure drop performance.



Design flexibility makes possible heat exchangers in many shapes . . . and in sizes up to 106" in length, with either bolt-on or integrally welded headers. For longer flow lengths, cores can be welded together in series.



Handle up to 5 fluids or gases, even more, at once. This symbolic drawing shows how. If your job requires one stream or many—high or low temperatures or pressures—solve it with TRANE Brazed Aluminum Heat Exchangers.

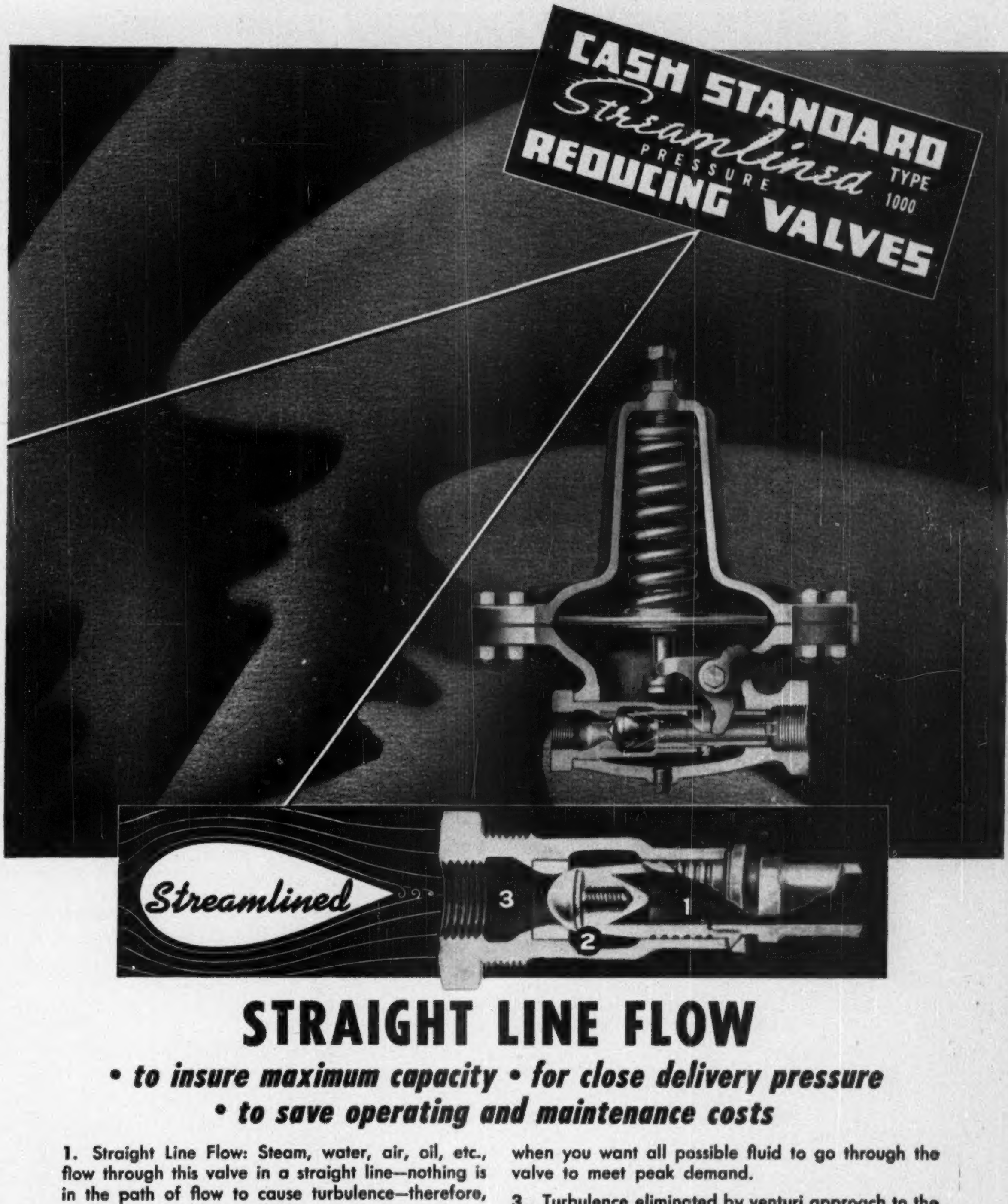
Write on your company letterhead for your FREE copy of "Extended Surface Heat Transfer Equipment."

More heat exchange . . . closer temperature approaches

TRANE brazed aluminum heat transfer surface

The Trane Company, La Crosse, Wis. • East. Mfg. Div., Scranton, Penn. • Trane Co. of Canada, Ltd., Toronto • 87 U.S. and 14 Canadian Offices

MANUFACTURING ENGINEERS OF AIR CONDITIONING, HEATING, VENTILATING AND HEAT TRANSFER EQUIPMENT



STRAIGHT LINE FLOW

• *to insure maximum capacity* • *for close delivery pressure*
• *to save operating and maintenance costs*

1. Straight Line Flow: Steam, water, air, oil, etc., flow through this valve in a straight line—nothing is in the path of flow to cause turbulence—therefore, peak flow is never a problem.

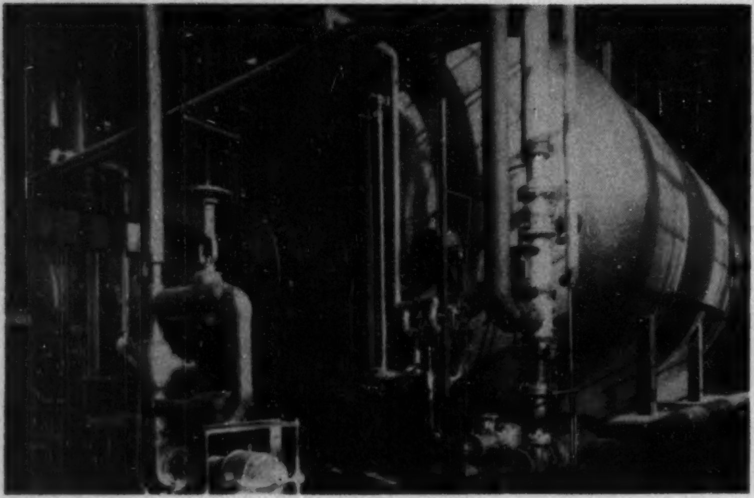
2. Inner valve is streamlined—no back eddies to hinder flow (see streamlined form above)—valuable when you want all possible fluid to go through the valve to meet peak demand.

3. Turbulence eliminated by venturi approach to the valve seat. This eliminates turbulence—it means better flow. The inlet pressure is confined to a small cylindrical chamber, the same being advantageous for high pressures.

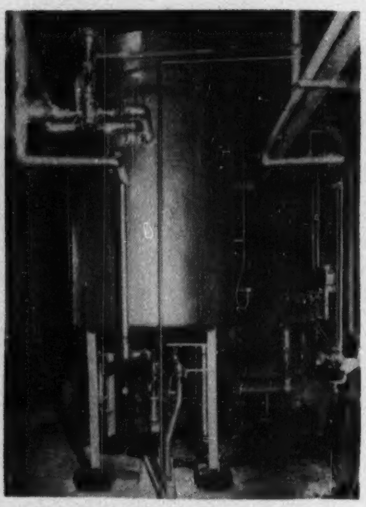
SEND FOR BULLETIN 962

CASH STANDARD CONTROLS.. VALVES

A. W. CASH COMPANY
DECATUR, ILLINOIS



1 24,000-gal. fermentation cooker prepares charge of soybean meal, calcium carbonate and starch for inoculation in fermenters.



2 1,200-gal. seed cooker prepares mash for inoculation in seed tank.

Bacitracin

A CHEMICAL ENGINEERING PICTURED FLOWSHEET

Fermentation processes are still very much in the fore with antibiotics. Here's the method used for making one of the important new ones, bacitracin.

Bacitracin is one of the important new antibiotics. It has antibacterial properties quite similar to those of penicillin.

The producing organism is the *bacillus subtillis*.

While the chemical structure of bacitracin is not known, its chemical analysis shows percentages of carbon, hydrogen, nitrogen, and sulfur closely approximating those of a typical protein. Acid hydrolysis of bacitracin yields amino acids.

The accompanying flowsheet describes the manufacture of bacitracin as done by Commercial Solvents Corp. at Terre Haute, Ind. Commercial Solvents is the only major producer of this antibiotic.

First, a flask culture of the producing organism is prepared for introduction into the intermediate culture tanks. Here mashing ingredients are inoculated. After about 6 hours' aeration with sterile air, enough growth has taken place to transfer the contents to a seed tank which has been charged with cooked mash.

Sterile air is introduced into the seed tank until the growth reaches the point of greatest reproductivity. Then the contents are transferred to a fermenter which has been partially filled with cooked mash. After inoculation, the balance of the cooked mash is added to the fermenter.

Temperature in the fermenter is automatically controlled. Sterile air is sparged in. Pressure is maintained at 5 psig. As the fermentation proceeds, the pH rises gradually. Rate of production increases during the fermentation.

Following the fermentation, the beer is pumped into the beer well. Sulfuric acid is introduced into the stream to lower the pH. Agitation in the beer well is controlled by the liquid level. As the level goes up, speed of the agitator increases, and vice versa. Filter aid is added.

A plate and frame filter press removes filter aid and bacterial cells, leaving the bacitracin in solution.

Butanol is used to extract the bacitracin in countercurrent centrifugal solvent extractors. Butanol that goes out with the spent beer is recovered by distillation.

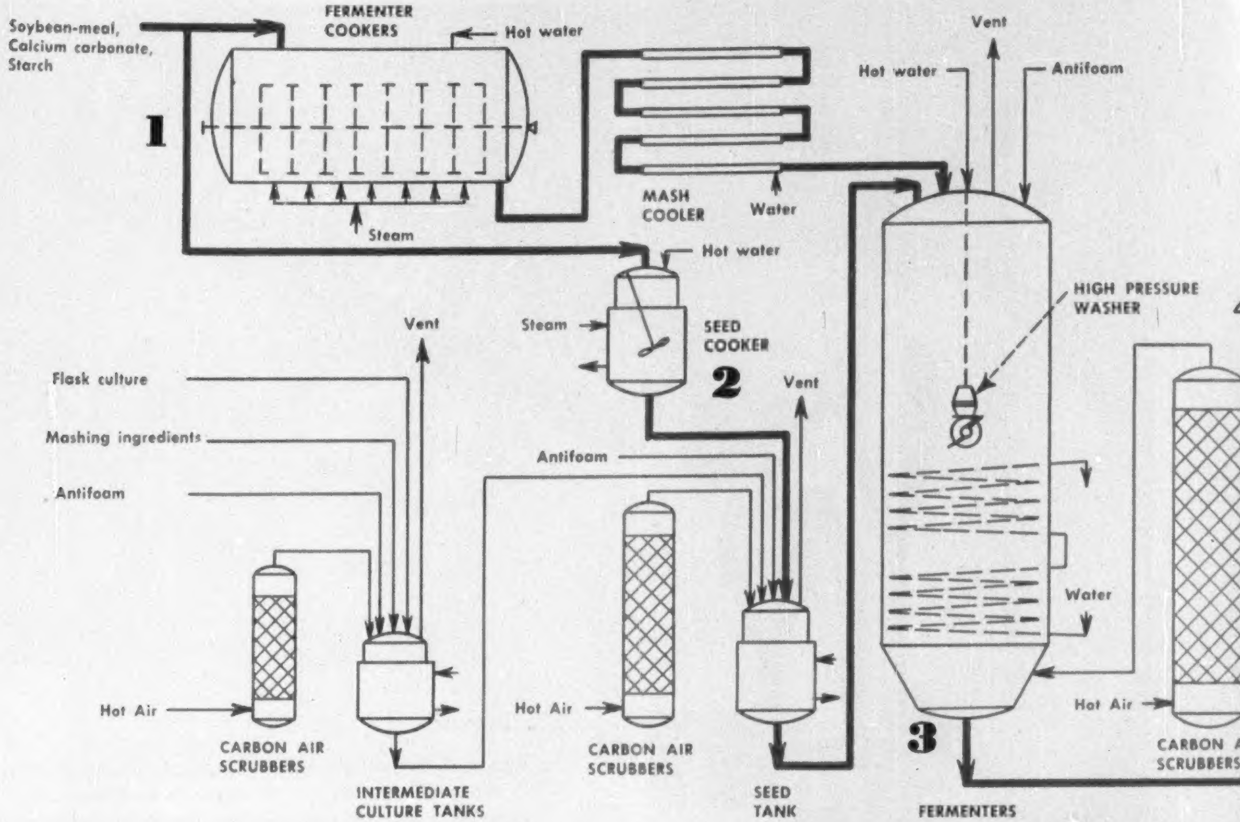
Butanol containing the bacitracin is charged to a vacuum concentrator, where a constant-boiling mixture of butanol and water is removed.

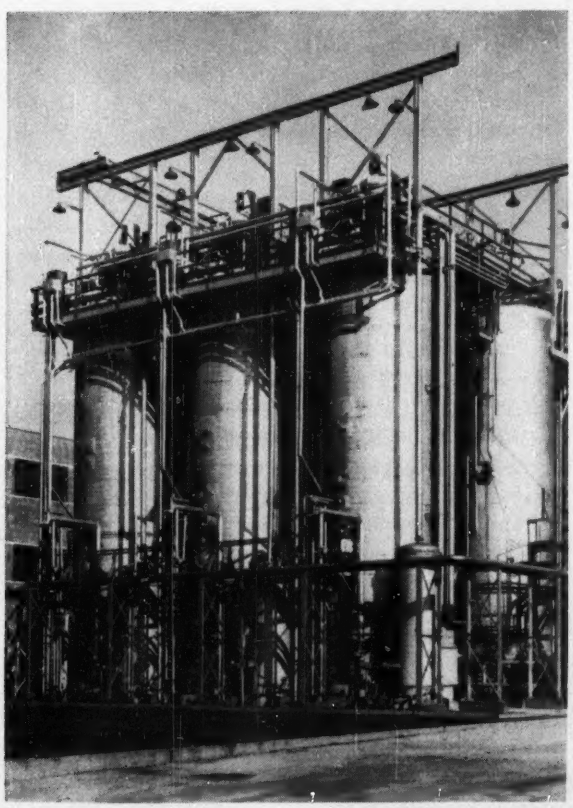
After char-treating the aqueous concentrate, the filtrate passes through a bacteriological filter before going to a bulk tray dryer. Drying yields a powder which is ready for formulating into pharmaceutical preparations.

Air used in the various steps in the process is heated above the dewpoint to insure a sterile supply. Small steam heated preheaters are installed in the air lines leading to the carbon air sterilizers. Each intermediate culture tank, seed tank, and fermenter has its own steam preheater and carbon air sterilizer.

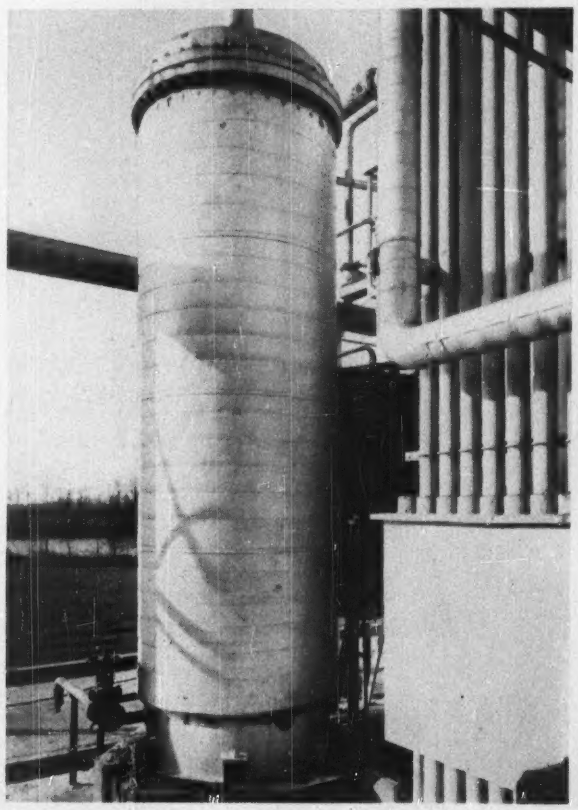
Sterile air is used to blow the contents of the intermediate culture tank into the seed tank, and to blow the contents of the seed tank into the fermenter.

Cooking of the mash that goes into the fermenters is done by sparging live steam into the charge. The vent valve is closed after the air is displaced, and the charge temperature is raised to 250 deg. F. approx. After holding at this temperature for an hour under agitation, the charge is cooled prior to use in the fermenter.



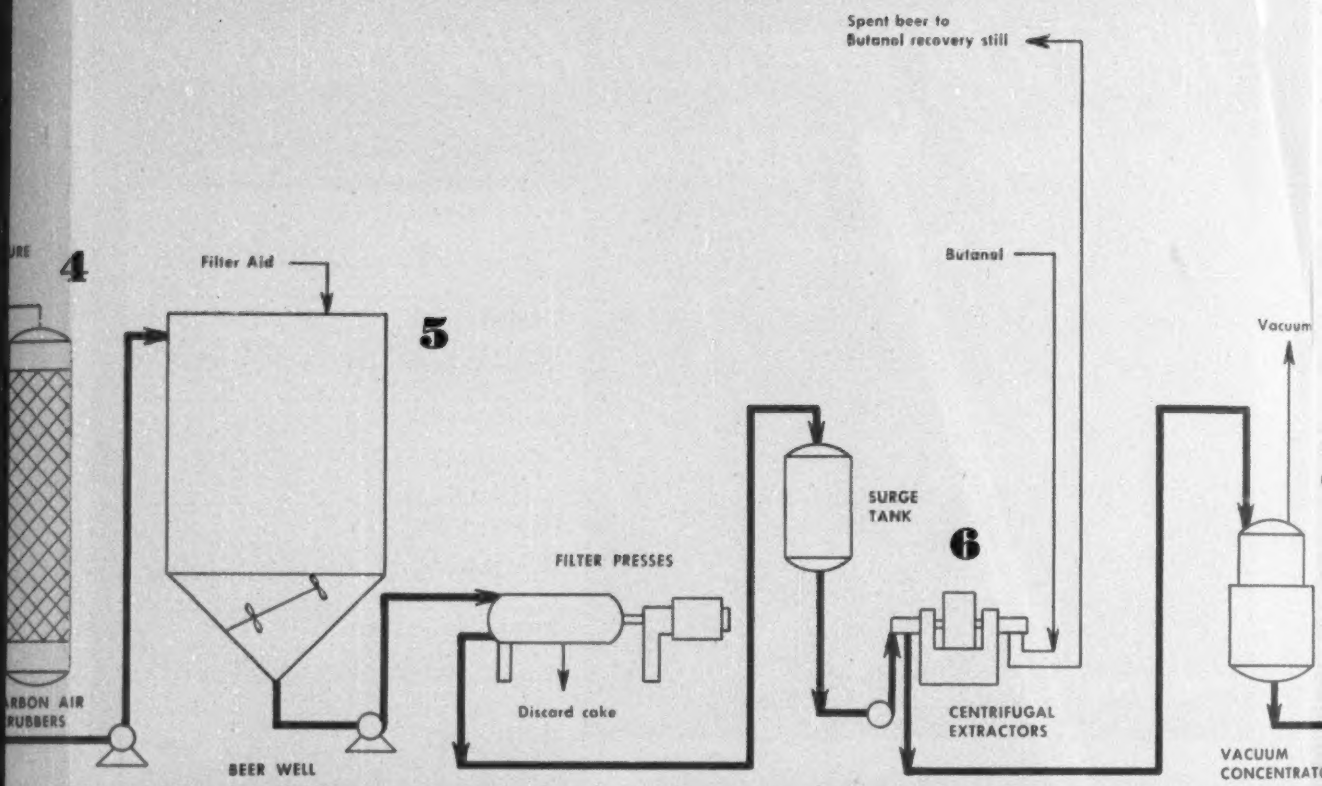


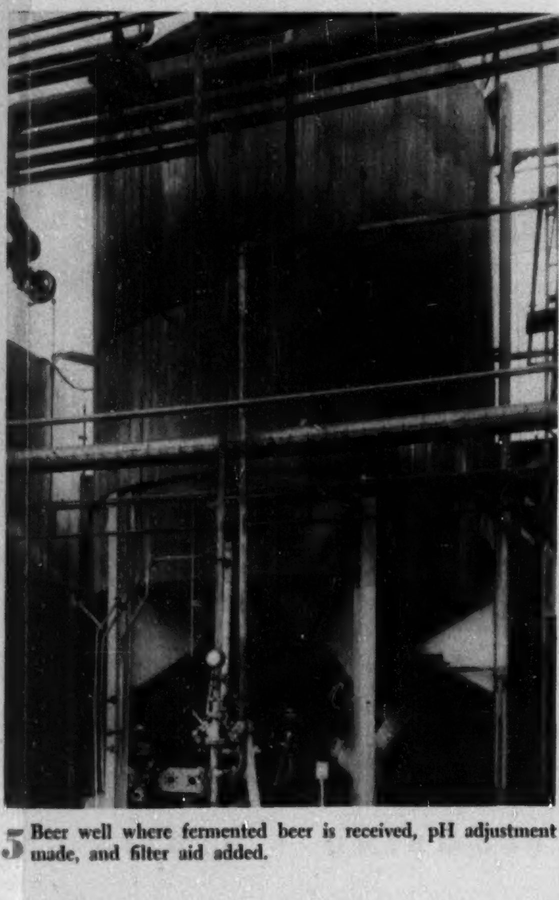
3 Fermenters where cooked mash is inoculated with seed. Sterile air is sparged in, pressure is maintained at 5 psi.



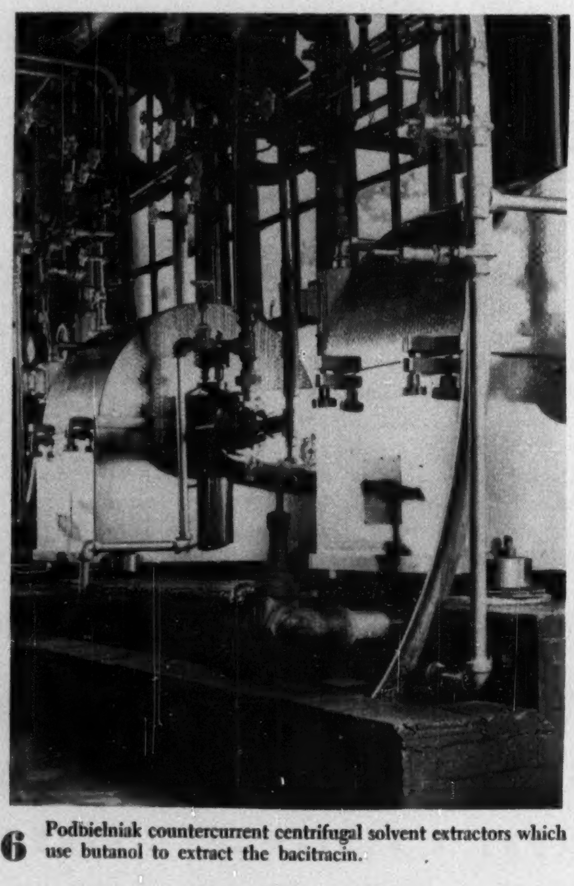
4 Carbon air scrubbers used in conjunction with small steam preheaters to insure a sterile air supply to the fermenters.

5



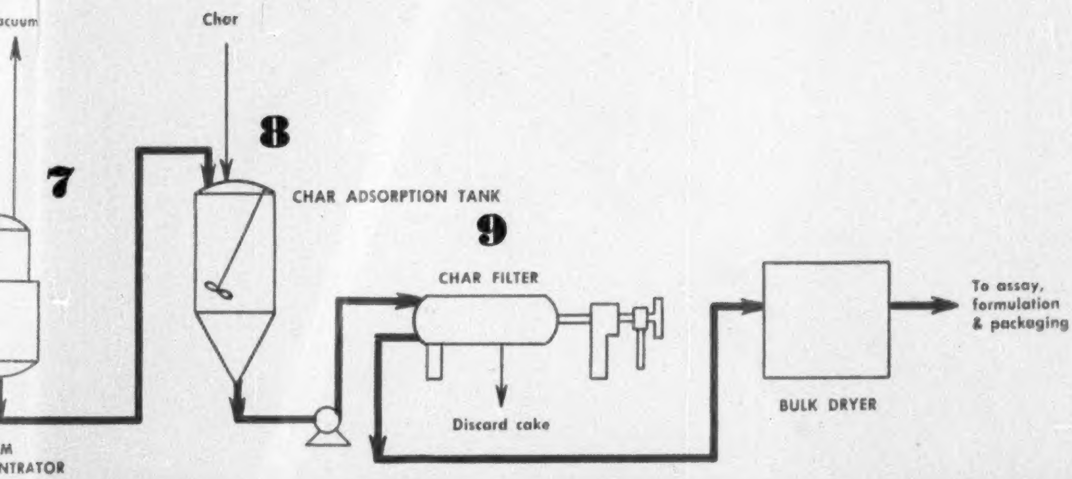


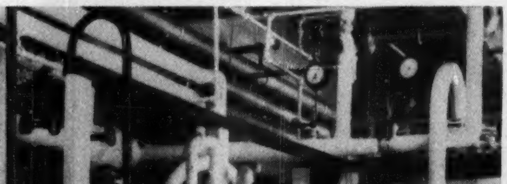
5 Beer well where fermented beer is received, pH adjustment made, and filter aid added.



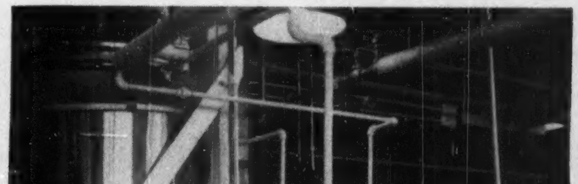
6 Podbielniak countercurrent centrifugal solvent extractors which use butanol to extract the bacitracin.

7 Vacuum
butanol

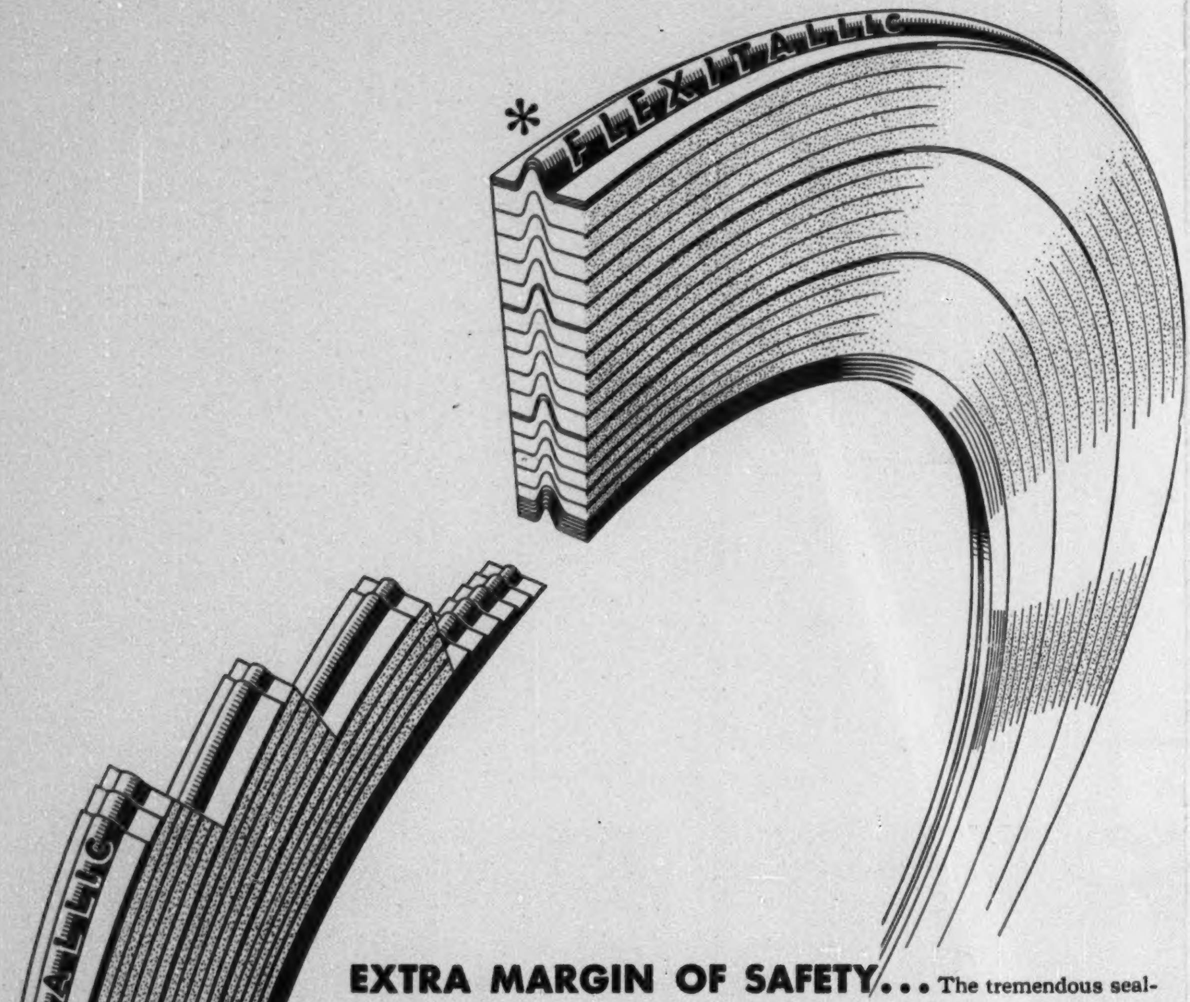




ucuum concentrators remove a constant boiling mixture of tanol and water, leaving an aqueous concentrate.



8-9 Char adsorption tank and char filter remove colors and odors from the aqueous concentrate.

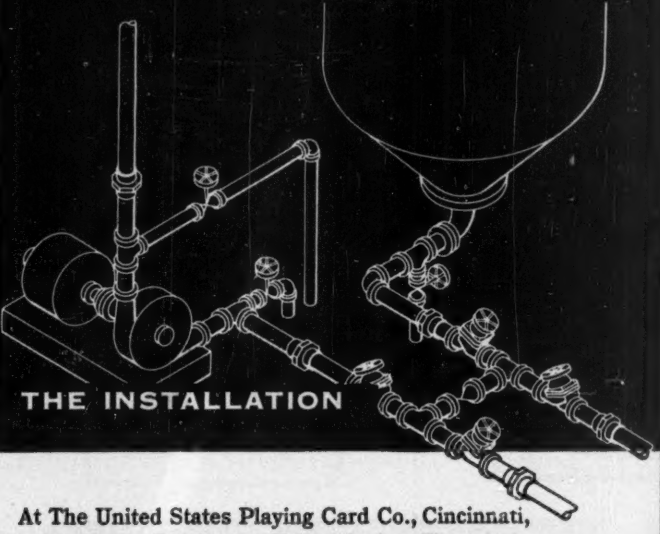


*
FLEXITALLIC
FLEXITALLIC

What a Difference in Valve Behavior

...on Heavy Coating Liquids

for example



THE INSTALLATION

At The United States Playing Card Co., Cincinnati, using Crane Diaphragm Valves in handling paper coating "enamels" from storage tanks to pumps.

VALVE SERVICE RATINGS

SUITABILITY:	None other like it
FEATURES:	Fluid can't get into bonnet
MAINTENANCE COST:	None
SERVICE LIFE:	No sign of wear after 3 years
OPERATING RESULTS:	Trouble and waste stopped
PRICE:	O.K.—No premium
AVAILABILITY:	Crane Catalog item—No. 1610

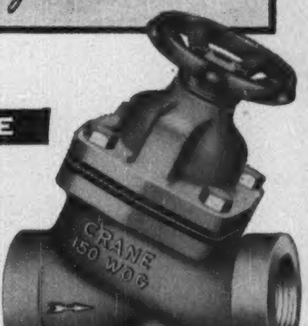
THE CASE HISTORY

Previously, ground plug cocks and conventional gate valves were used. During normal shutdowns the heavy coating liquid would build up on seating surfaces, in stem threads and working parts. The cocks and gates would "freeze up"; were hard to operate, couldn't be shut tight. Recurring maintenance, cleaning, and replacements were a costly, annoying problem.

Switching to Crane Diaphragm Valves solved the problem. Their sealed-to-fluid bonnet and soft disc insert did the trick. None of the 48 Crane valves installed beginning more than 3 years ago, has needed service of any kind. They continue to operate freely and easily.

THE VALVE

There are many more ways you can benefit by complete, dependable isolation of fluid and valve working parts. Crane Packless Diaphragm Valves are equally effective under corrosive conditions, and on erosive fluids—sludges, slurries, etc. They also keep your product contamination-free. Choose these valves to your needs from a wide variety of body, disc, disc-insert, diaphragm, and lining materials. See your Crane Catalog or local Crane Representative.



THE BETTER QUALITY...BIGGER VALUE LINE...IN BRASS, STEEL, IRON

CRANE VALVES

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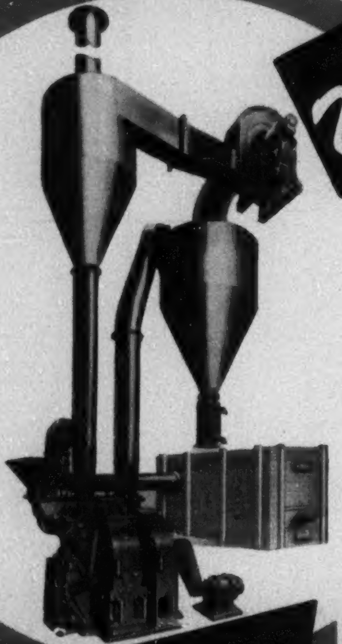
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

RAYMOND

Why FLASH DRYING?



for

CHEMICALS
PIGMENTS
FILTER CAKE
TREATED CLAYS
FOOD PRODUCTS
SYNTHETIC RESINS

RAYMOND
Flash Drying
CATALOG
No. 54A

. . . ***because:***

1. **You get faster drying.** Fine particles, pulverized in the mill, are stripped of moisture as fast as they leave the grinding chamber. The process is shortened to a fraction of the time required by other methods.
2. **Also a better product.** Close control of dryness and fineness insures uniform finished material. Instantaneous exposure of fine particles to hot air permits safe handling of heat-sensitive materials without detriment.
3. **Maximum thermal efficiency** due to high inlet temperatures used, and direct intimate contact of fine particles with hot gases or warm air. Heat source may be either direct or indirect. In some cases waste heat is utilized.
4. **Plant simplification.** Drying, grinding, classifying and elevating are combined in a single unit of equipment, eliminating separate dryers and saving rehandling of materials.
5. **Favorable cost factor.** Flexibility of installation makes it easy to fit plant layout without costly alterations. Operation is automatic, continuous and dustless, requiring minimum supervision. Low power and maintenance costs contribute to overall economy.

For further details, see Catalog 54-A

COMBUSTION ENGINEERING, INC.

Raymond
PULVERIZER DIVISION

1311 NORTH BRANCH ST.,
CHICAGO 22, ILLINOIS

SALES OFFICES IN
PRINCIPAL CITIES

GUIDED TOUR CONTINUED

Money-saving tips on how to get your patent.

There's a way to do it that'll save you time and headaches, too. This is your quick run-down of what you should—and shouldn't —do (*You & Your Job*).

Shifting U. S. chemical map.

Here's the first detailed and reliable picture of the chemical industry's growth by regions. It shows exactly what's happened since 1947 (*Economics*).

What's new this month.

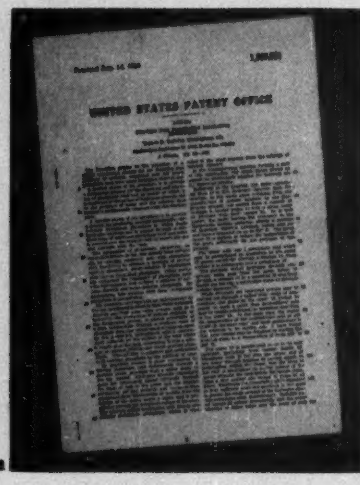
UOP patents the use of vapor compression in low-temperature fractionation, says it cuts down the number of trays for separating close-boiling compounds. And the latest in oil shale technology, say the patents, is to retort it underground (*Tomorrow's Technology*).

AND—Index of Advertisers precedes your Reader Service section inside the back cover.

You and Your Job Edited by Richard V. Reeves

Shell Oil Co.

Your Idea . . .



. . . Its legal protection

How to Get a Patent

Are you up-to-date in your patent know-how? Here's a concise run-down of most of the procedures, pitfalls, sources of information and professional help.

What do you need to get your name on a patent?

If your idea is patentable you'll need: (1) a good patent lawyer; (2) about 300 bucks; and (3) a whale of a lot of patience. Naturally, this assumes that you're a free agent. If you work for a sizable company you've probably signed an agreement to assign all patent rights to your employer and the company's patent department handles all liaison with the U.S. Patent Office. But, in either case you may be interested in knowing how the legal machinery of the Patent Office works.

▶ **Well, What's A Patent?**—Contrary to what many people think, a patent is *not* the right to make, use, or sell an "invention." It *is* the right to exclude others from making, using, or selling the invention for a period of 17 years. Patents cannot be extended unless by a special act of Congress.

▶ **What's Patentable and What's Not?**—The law says that any person who "invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvements thereof, may obtain a patent," subject to the conditions and requirements of the law.*

The words "new" and "useful" are important here. You can't get a patent:

- If your process or equipment was either known or used by anyone else in the U.S.
- If it has been described in a printed publication.
- If it was either in public use or for sale in the U.S. or a foreign country more than one year prior to your patent application.

The word "useful" means that the process must work and must have a useful purpose. You can't get a patent on a "perpetual motion" gadget. The phrase "new and useful improvements" has a limited meaning too. A simple change in construction of a machine, for instance, is not patentable—*unless* the change brings about a "new, useful and unexpected result or effect." If it makes the difference between success and failure it's patentable.

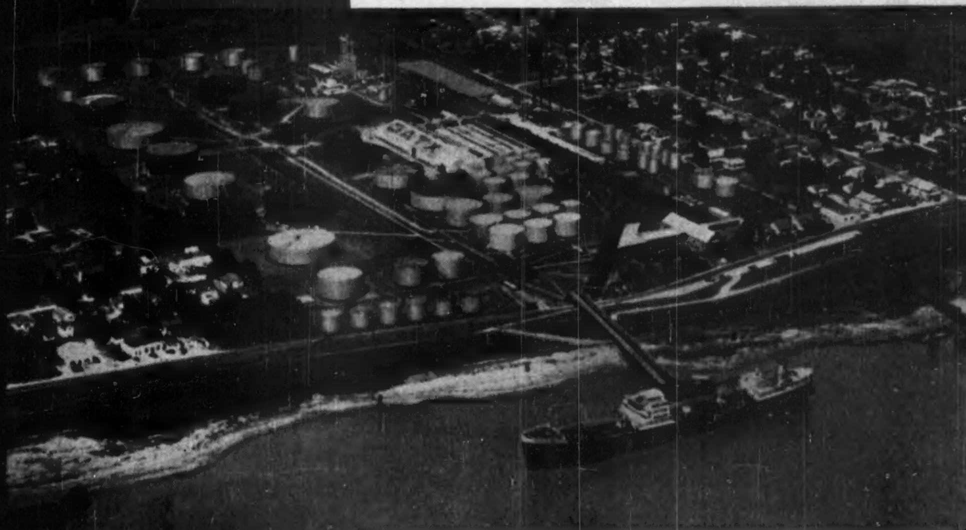
It's also probably worth mentioning that the McMahon act—The Atomic Energy Act of 1946—specifically forbids the patenting of anything that has to do with fissionable material.

O.K., suppose you're convinced that you've got a red-hot process and you'd like to get it under legal wraps in a hurry. What's next?

You can get plenty of dope from the U.S. Patent Office, including a booklet called "General Information Concerning Patents." It's free and it's up-to-date. But if you don't know

---

*At the beginning of this year, an important change in the law went into effect. Part of that change was the substitution of the word "process" for what the law has previously called an "art." What this means in simple terms is that new uses of old products and processes can be patented if the requirements of an "invention" are fulfilled.



your way around, one of the best investments you can make is the Patent Office's "Roster of Attorneys and Agents Registered to Practice before the United States Patent Office." It costs $1.75 and lists both patent attorneys, who are lawyers, and patent agents, who are not. They are equally qualified to get you a patent but you may be better off with an attorney since he can later conduct litigation for you if necessary.

One thing to remember: It's a good idea to steer clear of attorneys and agents who advertise in popular magazines or telephone books. As with doctors, most lawyers consider it unethical to advertise their services and the Patent Office estimates that only about 2 percent of the agents registered do such advertising.

Once you've engaged a lawyer you can breathe easier but there are still hurdles aplenty.

Your lawyer's first and most time-consuming job will be to search the patent office records for similar inventions to see if yours is sufficiently new or different from existing applications to warrant the filing of an application. His fee will depend largely on the time this search consumes.

If your invention passes this first hurdle, he will advise you to file an application. In doing this your lawyer will ask you to execute a power of attorney or authorization of agent which will be filed in the patent office along with your application papers. After this point all correspondence and communication will take place between your lawyer and the office. The patent office sends two copies of all letters to the attorney so that he may forward one to you, the inventor. You retain the authority to remove the attorney by revoking his power or authorization.

The patent application itself includes three integral parts:

1. A written document consisting of a petition, a description and claims, and an oath;
2. A drawing which conforms to rigid specifications; and
3. A filing fee of $30 plus an additional dollar for each claim over 20.

The description and claims must include the following:

- Title of the invention; or a preamble with the name, citizenship, and residence of the applicant and the title of the invention.

• Brief summary of the invention.

• Brief description of the drawing or drawings.

• A detailed description. This must be clear enough to enable any person skilled in the art to make and use the invention. It must also be in line with a number of other rigid specifications.

• Claim or claims.

Models are rarely required nowadays but drawings are. As a competent draftsman, your attorney may ask you to make the drawings yourself. In this case you'll need a copy of the "Guide for Patent Draftsmen" available from the Commissioner for 75 cents. It lists the specifications required by the office. If you don't do the drawings yourself, you can hire a patent draftsman to do them.

The rest is patient waiting; the whole process of getting a patent takes about three years. The big job is the search made by the Patent Office examining division. There are 70 of these divisions, each dealing with a specific field of invention. Right now the patent office has about 1,880 employees, half of them examiners, who process over 60,000 applications per year. About four out of every seven applications filed are granted.

The examiners search the prior U.S. patents and the prior foreign patents available in the office.

After the search, a patent is granted or a claim is rejected. If rejected, the reasons are given and the inventor may amend the application and file again. After this there may be additional rejections and additional amendments until a final rejection by the examiner.

If you receive a final rejection you still have several recourses. You can: (1) request an interview with the examiner to plead your case personally; (2) amend your application by cancelling the rejected claims; (3) appeal to the Board of Appeals in the patent office; or (4) abandon your application.

Whether you get your patent with or without a struggle doesn't necessarily mean your worries are over for the next 17 years. We mentioned earlier that a patent was *not* the right to make, use, or sell your invention, but that it was the right to exclude others from making, using, or selling the invention. For instance, suppose you get your patent and you're happily peddling the Gro-No-Mo feed supplement for stunted piglets. One

You and Your Job, *cont. . .*

day you get a scurrilous letter from Ace Antibiotics telling you to stop making *their* product, Patent no. 888,-888. Do you call in your secretary and dispatch a letter suggesting an ignoble course of action, citing your own patent, no. 999,999? If you do, you may end up with a lawsuit that'll put you out of business.

The smart thing to do is call your lawyer and have him look into Ace's patent. It may be that it overlaps yours, in which case you *could* end up paying royalties to use your own patented process. That's a remote case but it points up the reason why it's never smart to get tangled up with the law unless you're a lawyer.

Another thing to remember is that the Commissioner of Patents is not a policeman. If somebody is infringing your patent don't howl to the Commissioner. He'll turn a deaf ear. Instead, call your lawyer again. Chances are the infringer never heard of your patent. When your lawyer tactfully points out that he's illegal, the infringer will probably stop; if he doesn't you can bring suit and recover damages.

You may find before the 17 years are up, that you've earned every penny of the million dollars your patent *may* bring in.

ATTRACTING GRADUATES

. . . A New Idea

How to turn down an applicant for a job and still keep him as a friend is a problem of personnel people to which public relations could wisely devote more time.

From 12 to 20 people are interviewed for every one hired. Although the figures differ among individual companies, still standing out is the fact that for every employee on the payroll there are close to a dozen people who have been told, with varying degrees of diplomacy, that they and the company are not compatible.

Generally it is the fault of the applicant if he is turned down by a company during these days of high employment. One of the outstanding reasons, and particularly among recent high school graduates, is that the applicant comes looking for a job with a company while knowing little or nothing about the company's requirements. Companies whose names are

well known but whose products and requirements are not are the ones most plagued by the problem.

Solving it and doing it in such a way that you really help the groping job applicant to the point where he becomes a steadfast friend is a neat trick if you can do it.

A step in the right direction is underway in Cincinnati. Hub of the entire project is a new publication called *Decision.*

Basically, Decision, subtitled "The Graduate Guide to Business," is an annual slanted to get directly at the heart of this particular problem. The book is given free to every high school senior in the city. It contains nothing but unusual editorial type advertisements describing the personnel requirements and employment opportunities of local companies, and is practically a text for the job hunter.

Companies in the area buy space in the publication with the object of spelling out just what employment opportunities are available in their company. For example, Proctor & Gamble used their space to tell what products are made at P&G, a little about the company, where to apply, and the types of people they are looking for. It spells out in simple language what P&G does and does not have to offer.

High school graduates, forearmed with the information in *Decision* know beforehand if they might fit into a certain company's operation. If they could fit in, the company gets a good look at a graduate who has already had a reasonably good prescreening. If the graduate could not fit in, the company's personnel people are spared time with applicants who could not possibly meet the particular needs of the company. Also, the applicant is spared the time involved in calling on the company.

MARKETING

. . . *To Top Management*

Marketing men gradually are getting a stronger voice in determining the policies of leading manufacturers. In the last decade, the proportion of marketing experience among all members of all boards of directors of some 30 largest-selling companies gained at the expense of other major types of business experience: engineering, financial, legal and production. Of combined experiences reported in the 10-year period: Engineering declined

from 9.8 to 9.3 percent; legal declined from 11.7 to 9.3 percent; financial declined from 31 to 28.7 percent; legal declined from 11.7 to 9.3 percent; and production from 23.1 to 21.3 percent. In contrast, "administrative" increased from 43.6 to 45.7 percent. "Other" (including agricultural, educational, labor relations, military, purchasing, transportation) rose from 5.1 to 5.4 percent. Marketing experience expanded from 24.7 to 26.7 percent.

By industries, marketing experience proportionately is strongest on food-company boards. In 1951, 30 of all these 75 directors—or 40 percent—had marketing experience. Among the other groups in 1951, marketing experience was reported for 27 percent of chemical directors; 25 percent of both metals and electronics; 20 percent of oil; 16 percent of rubber; and only 7 percent of motors.—*Management Review, 3/53*

BENEFITS

. . . Moving Bills

A survey of companies in the Cleveland area—which is considered to be representative of U. S. industry as a whole—has failed to discover any uniform policy for paying the moving bill of newly-hired executives.

The importance of the position, and the determination of the company to get a particular man to fill the particular job, are important factors in management thinking. Naturally, if a firm requests a person to call for an interview with an eye to hiring him, it normally pays his expenses for the trip; and if he joins the organization after the interview, chances are that the company will pick up the tab on the expenses of moving his household goods.

As for hotel and incidental costs, policy varies, but generally this comes out of the executive's own pocketbook. Some companies will pay for the new man's hotel room for a limited time, but usually this does not include his family. A month to locate living quarters and to get his feet on the ground is about as much as even the most liberal companies allow the newly-hired executive, at least as far as paying his hotel bill is concerned.

One or two weeks is a more usual length of time; and, as a rule, the bill may not cover meals.

TROUBLE! PLANT 60-MI AWAY

TAKEOFF FROM MAIN PLANT

MINUTES LATER, TO THE RESCUE

AIR TAXI

. . . Moves Management Fast

If you have half a dozen plants within a two-or-three-hundred-mile radius of one another, and if your top executives are sometimes needed—in a hurry—at one or more of these plants, here's a novel idea you might want to look into.

Rockwell Manufacturing Co. uses a new seven-passenger S-55 Sikorsky helicopter to shuttle its executives between the company's main offices in Pittsburgh and seven plants within an approximate 200-mile radius.

Because of the widespread and diverse activities of the company, transportation of officers and staff members is regarded by W. F. Rockwell, president of the firm, as a key to effective management coordination and efficient utilization of management manpower. Since most Rockwell Pennsylvania and Ohio plants are located in small, often isolated communities, commercial air and rail travel facilities have in the past resulted in the loss of hundreds of hours of executive time each year.

"The obvious solution to our prob-

lem," Rockwell explained, "was an airplane. But when we investigated the possibility, we found that our position would not be greatly improved. It's at least a 30-minute ride from our Pittsburgh headquarters to the nearest airport, and in some of our plant cities suitable landing facilities are not available, or are some distance from our plant sites. A helicopter seemed to afford the most practical solution to our specialized problem—that of providing a taxi service between plants."

Initial operations since the first of the year have indicated that Rockwell and his associates are able to visit as many as three plants in a single working day. One a day was the former average by auto or rail, with two an absolute maximum, and this often necessitated spending a night, and sometimes two, on sleepers.

The Helicopter's daily "schedules" are determined on the basis of travel requests by officers and staff members who designate in advance their travel requirements. On a typical day, the helicopter leaves the Rockwell plant in Pittsburgh with three to five members of the organization, and sometimes with an item of equipment needed immediately by a plant on the itinerary. The first stop may be at Lestonia, Ohio, 60 miles distant. Forty miles farther is the Barberton (Ohio) division, where valves are manufactured, and about 90 miles beyond is the company's regulator division at Norwalk, Ohio. On this particular itinerary, the helicopter will enable company officials to make three two-hour stops and still return the 191 miles to Pittsburgh the same evening. Often, a Rockwell representative will be "dropped" at a plant to be picked up later for the return.

Though many outfits own 'copters none are used for executive and staff travel. Usually they patrol oil and natural gas pipelines.

Rockwell says "The real indication of the effectiveness of the helicopter is that the company is now giving serious thought to a priority system so that they can take care of all the requests for travel."

AN ENGINEER

. . . *Another Definition*

An engineer is a person who passes as an exacting expert on the basis of

being able to turn out with prolific fortitude an infinite series of incomprehensible formulae calculated with micrometric precision from vague assumptions based on debatable figures taken from inconclusive experiments carried out with instruments of problematical accuracy by persons of dubious character and questionable mentality for the avowed purpose of annoying and confounding a hopeless commercial group of esoteric fanatics referred to all too frequently as "practical engineers."—*The Kentucky Engineer*

LABOR

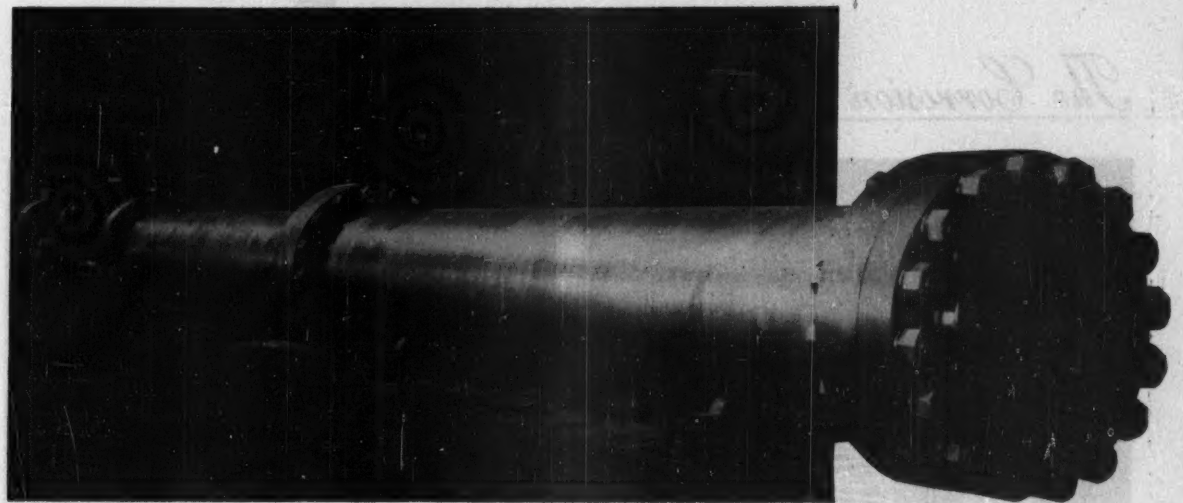
. . . In 1955

Under a prosperous peacetime economy, the U. S. labor force can be expected to expand to about 89 million by 1975 (in 1950, it was 64 million; in 1920, 41 million). The projected rate of growth—which represents an average annual increase of 1.3 percent during the next 25 years—would be slightly less than that for the past three decades. Some acceleration, however, is expected during the 1960's when the large crop of babies from World War II and the early postwar period attains working age.

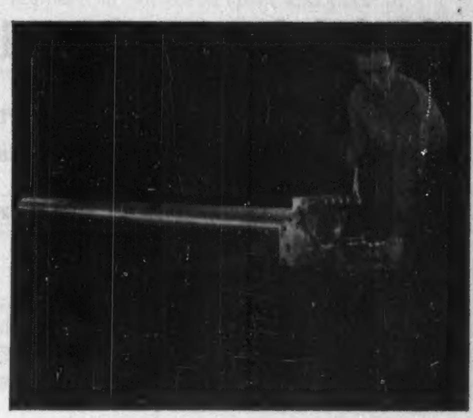
The expected expansion in the labor force between 1950 and 1975 will largely reflect an increase in the number of people coming of working age, rather than changes in labor force participation. Actually, the over-all labor force participation rate for people 14 years old and over in 1975 will probably represent little change from that recorded in 1950 (57 percent). There will be some changes, however, within this group. Some decline is expected in male labor force participation, virtually all of it among youths who will be spending, on the average, more years in school—and among men 65 years old and over, a greater proportion of whom will be retired if present pension trends continue.

Also, as time passes, women will occupy an increasingly important role in the economic life of the nation. In 1920, they represented only 21 percent of all workers; the proportion had advanced to 28 percent in 1950, and is expected to reach 33 percent by 1975. A particularly large increase is foreseen among women in the middle and older age groups.—*Current Population Reports 12/10/52*

—End



Not like PEAS IN A POD



Almost every pressure vessel we build presents its own particular problems. The most effective methods in one case often won't do in the next. We couldn't, for instance, expect to employ the same techniques on both the vessels shown here.

One is very small and is used in a highly-specialized process. The other, a giant, is much more conventional in style. And in between these two extremes we have made just about every size and type you can name. They all have their differences, all create problems.

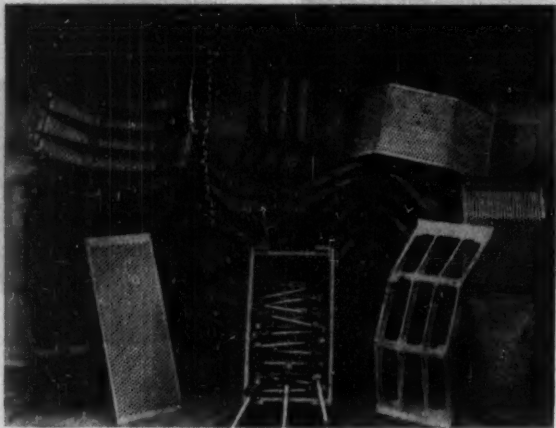
The point is, we're equipped to find the answers to these problems. And, with the answers at hand, we can furnish the steel, the forging equipment, the heat-treating, the machining facilities, and the skilled manpower needed. When you commission Bethlehem to build a forged pressure vessel, the job will be done correctly with every detail complete.

The next time you are planning reactors, filters, converters, separators, large autoclaves, or accumulators, consult a Bethlehem engineer. He will be glad to co-operate with members of your technical staff as they design the vessel or vessels you need.

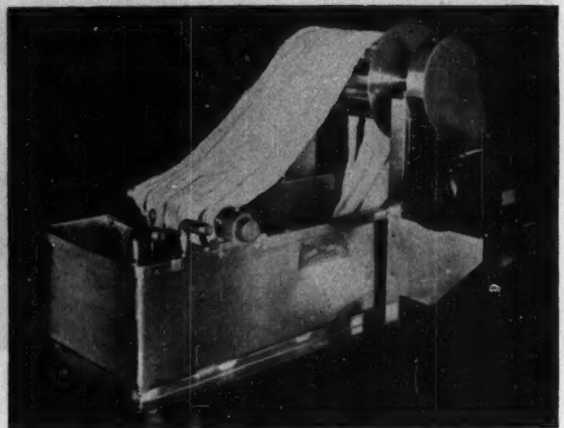
BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL



Acid circulating screens for pulp and paper mfg.



Dyeing machine for nylon yarns.

Molybdenum Stainless Steels

The corrosion resistance of these important materials of construction to a number of corrosives, with physical and mechanical properties, applications.

COMMITTEE OF STAINLESS STEEL PRODUCERS, American Iron and Steel Institute

NOTE: *This is one of a series on stainless steels. Refer to the first article in the series in the April issue for what to consider in the selection of stainless steels regardless of grade.*—EDITOR.

Generally, the most corrosion-resisting standard stainless steels for chemical processing work are the molybdenum-bearing grades. The addition of molybdenum has the specific effect of raising corrosion resistance of 18-8 stainless in such media as sulfurous acid, sulfuric acid, phosphoric acid, formic acid, and various hot organic acids. Resistance to pitting is substantially bettered. These grades also have the highest creep strengths at elevated temperatures of any of the standard stainless steels.

Type 316, the basic modification, gives useful service at room temperatures in sulfuric acid of concentrations lower than 15 and higher than 85 percent. Between 20 and 80 percent acid concentration, Type 316 is subject to rapid attack. As the temperature rises, the corrosion rate goes up accordingly, and even Type 316 is not very useful under high-temperature conditions. However, additions of ferric sulfate, copper sulfate, nitric or chromic acids to the solution will greatly reduce attack and has permitted many economical applications of Type 316. Type 316 is preferred to Type 304 where naphthenic acid at high temperatures is present.

Where extensive welding is in

(*Continued to page 310*)

Standard Wrought Molybdenum-Bearing Stainless Steels

AISI Types	Carbon	Manganese	Silicon	Phosphorus	Sulfur	Chromium	Nickel	Molybdenum
316*......	0.10 max.	2.00 max.	1.00 max.	0.040	0.030	16.00–18.00	10.00–14.00	2.0–3.0
316L......	0.03 max.	2.00 max.	1.00 max.	0.040	0.030	16.00–18.00	10.00–14.00	1.75–2.50
317......	0.10 max.	2.00 max.	1.00 max.	0.040	0.030	18.00–20.00	11.00–14.00	3.0–4.0

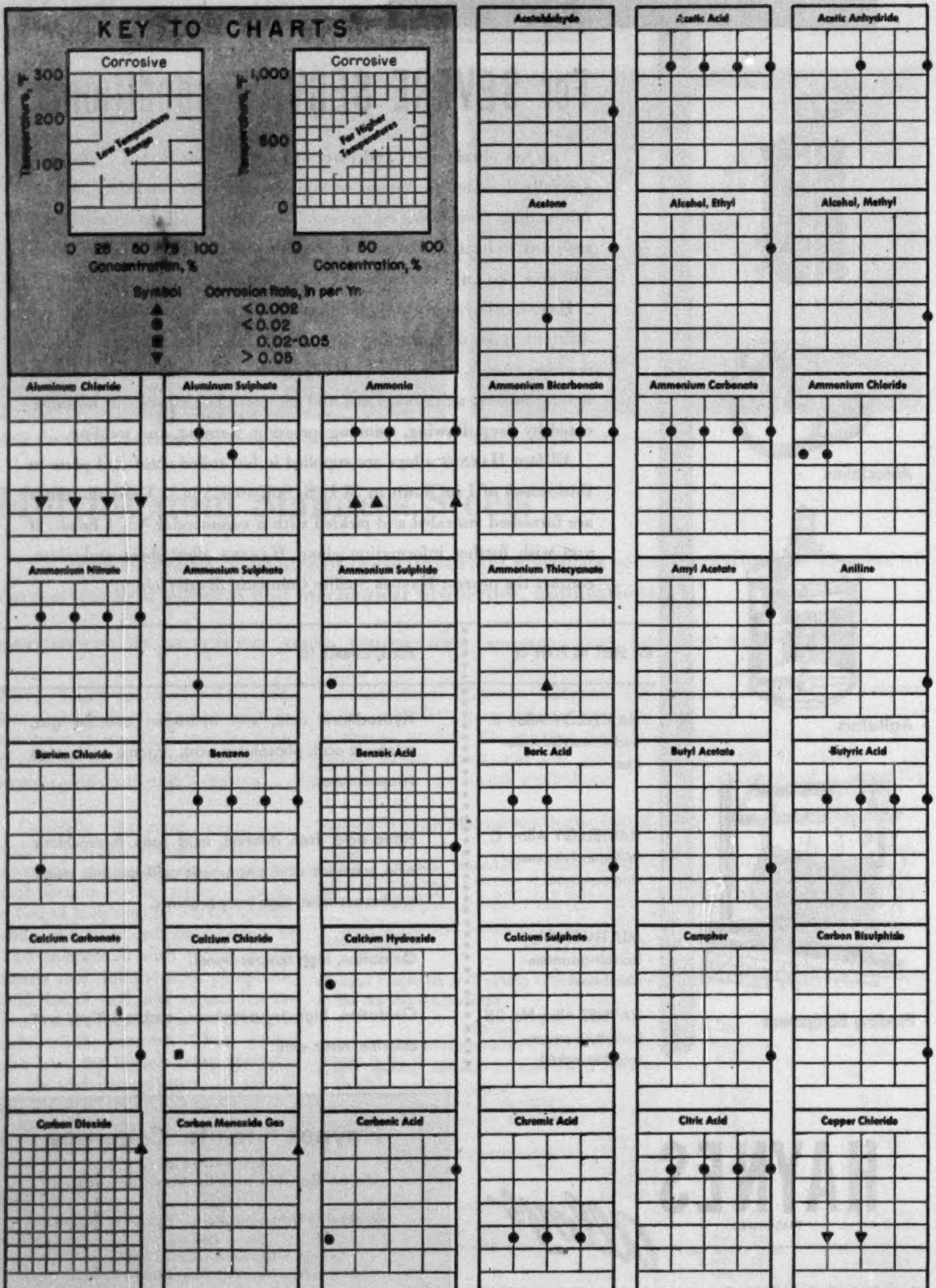
* Note: An additional modification of Type 316 is Type TS316 containing 1.75–2.50 molybdenum as required by NPA.

Physical Properties & Working Characteristics of Wrought Molybdenum Bearings Steels in the Annealed Condition

AISI Type		316	317
Modulus of elasticity in tension, psi........		28×10^6	28×10^6
Density, lb./cu. in........		0.29	0.29
Specific electrical resistance at room temp., microhms/cm./cm.^{2}........		74	74
Magnetic permeability, annealed........		1.003	......
Specific heat, Btu./lb./deg. F. (32–212 F.)........		0.12	0.12
Thermal conductivity, Btu./hr./ft.^{2}/ft./deg. F.....	212 F.	9.4	9.4
	932 F.	12.4	12.4
Mean coefficient of thermal expansion per deg. F........	32–212 F.	8.9×10^{-6}	8.9×10^{-6}
	32–600 F.	9.0×10^{-6}	9.0×10^{-6}
	32–1,000 F.	9.7×10^{-6}	9.7×10^{-6}
	32–1,200 F.	10.3×10^{-6}	10.3×10^{-6}
	32–1,500 F.	11.1×10^{-6}	11.1×10^{-6}
	32–1,800 F.	....	....
Max. continuous temp. without excessive scaling, F........		1,650	....
Melting point range, F........		2,500–2,550	2,500–2,550
Forging practice	Initial temp., F........	2,100–2,300	2,100–2,300
	Final temp., F........	1,700–1,750	....
Annealing temp., F........		Cool rapidly from 1,850–2,050	Cool rapidly from 1,850–2,050
Stress relieving, F........		400–750	400–750

Note: Wherever possible values given are from AISI Steel Products Manual, Section 24, April 1950 Where no AISI figures were available ASTM figures have been used (Ref. ASTM Technical publication No. 52A, Table XX).

Corrosion Resistance of Type 316 Stainless Steel



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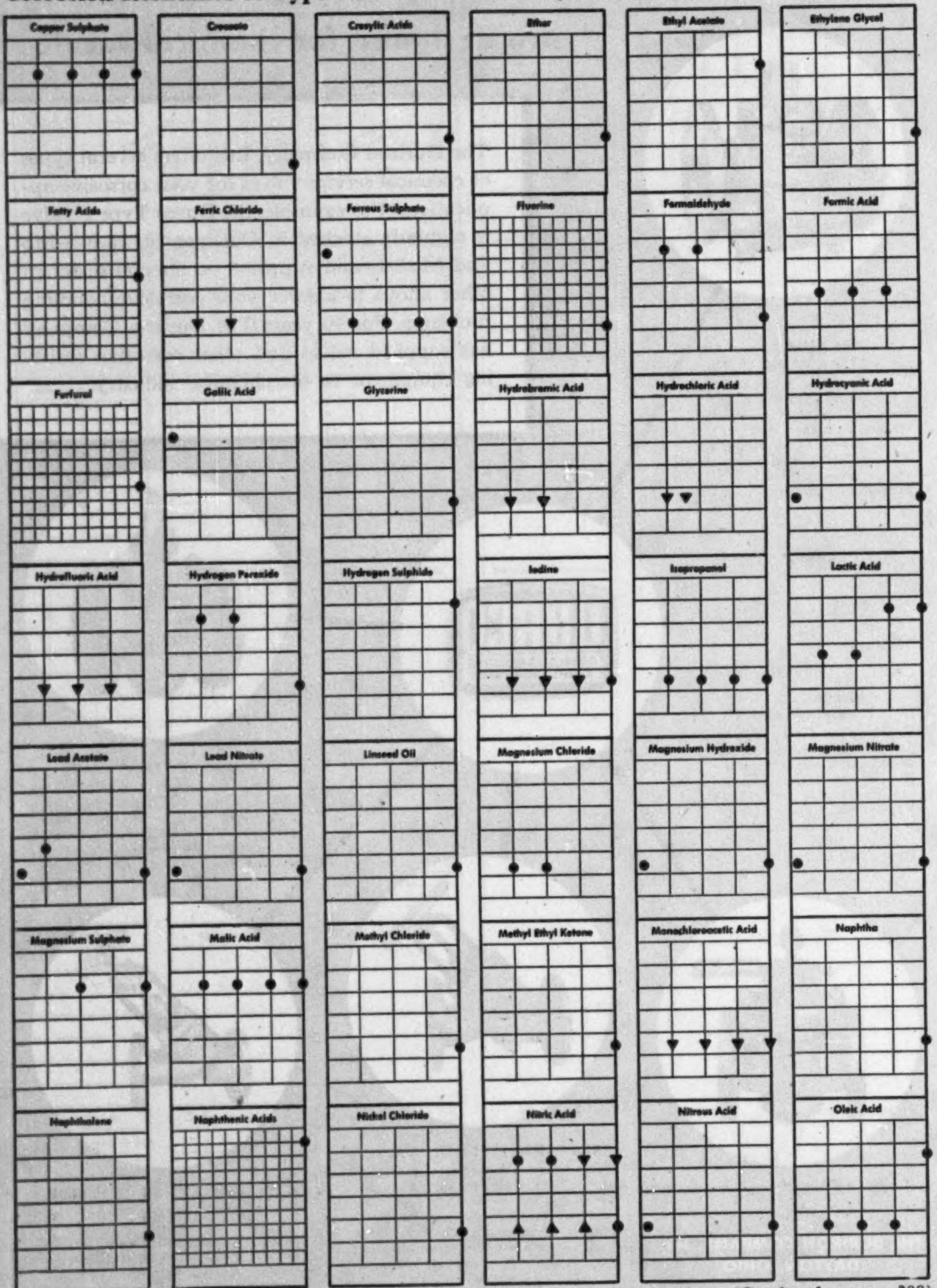
Corrosion Resistance of Type 316 Stainless Steel (cont.) . . .



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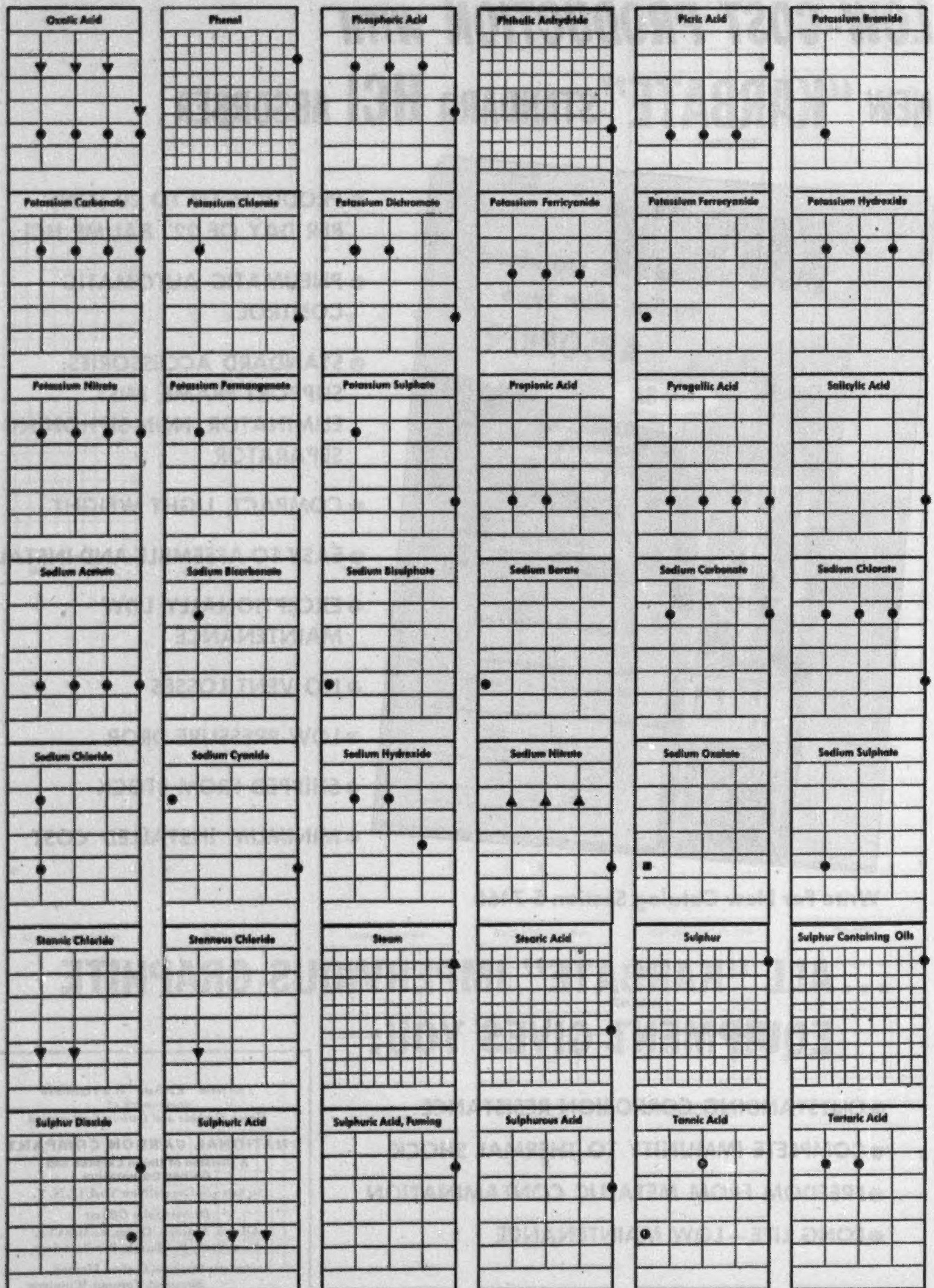
Corrosion Resistance of Type 316 Stainless Steel (cont.) . . .



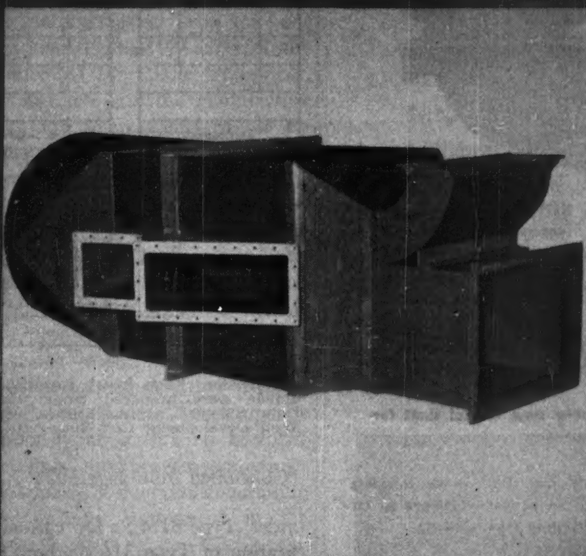
(Continued on page 310)

Is corrosion costing you money?

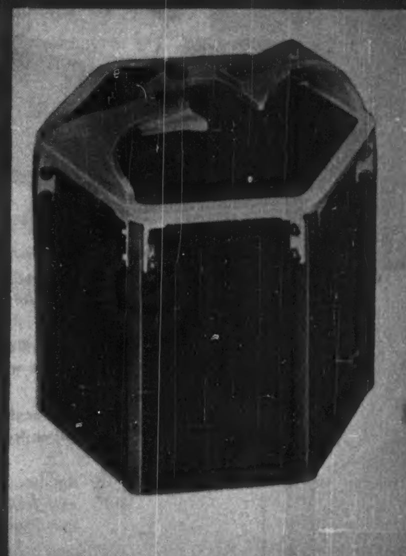
WRITE FOR FACTS ON RIGID, NON-PLASTICIZED

Boltaron 6200

A BOLTA-HARTWELL PRODUCT **POLYVINYL-CHLORIDE**



Exhaust duct of Boltaron 6200 made to special order for an electroplating plant.



Plating Barrel — Plating barrel fabricated of Boltaron 6200 rigid polyvinyl-chloride sheet and assembled with bolts of the same material.

Boltaron 6200 is the outstanding corrosive-resistant material on the market today and retains the exceptional properties of unmodified Polyvinyl-Chloride. It is a superior, chemical resistant product particularly adaptable to the plating industry for exhaust systems, acid and alkali baths and for carrying corrosive solutions of all kinds.

Availability: *Sheet Stock* in sizes approximately 30″ x 60″ — 1/32″ to 1″ thick; *Bar Stock* in 10′ lengths, ¼″ to 2″ in diameter; *Pipe* in ¼″ to 2″ sizes and in 10′ and 20′ lengths; may be threaded using ordinary pipe dies; *Fittings*, standard, threaded I.P.S. fittings carried in stock in ¼″ to 2″ sizes.

National distribution has been established through strategically located fabricators in the United States, selected and trained by the Hartwell Company to efficiently and economically use Boltaron 6200 for outstanding results. Direct your inquiries to

H. N. HARTWELL & SON, INC.

Industrial Plastics Division • Park Square Building, Boston 16, Mass.

PROPERTIES OF BOLTARON 6200

(Write for specific results of ASTM tests.)

Chemical Properties — Outstanding chemical resistance to organic and inorganic acids, alkalies, alcohol and foodstuffs. Laboratory tests are continuously carried on. Complete information available on request.

Thermal Properties — Excellent low temperature factor, high heat distortion temperature, low coefficient of expansion, non-flammable.

Mechanical Properties — Great strength, light weight, high impact strength, non-toxic, ability to be drawn, formed, molded, machined and welded by hot gas technique, good deformation and abrasion resistance.

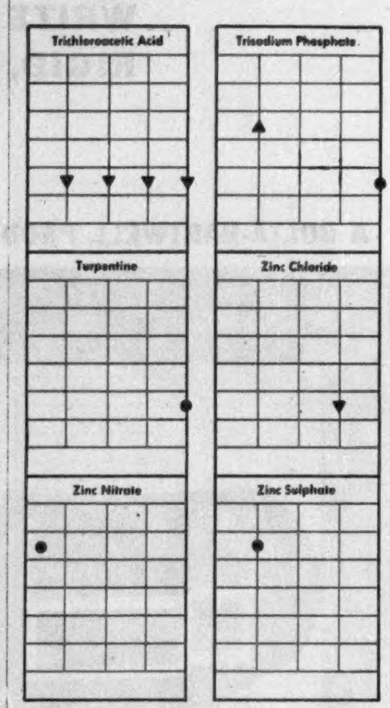
PARTIAL LIST OF USES

Electroplating	Food Processing
Anodizing	Dairy Products Processing
Dyeing & Bleaching	Textile Processing
Tanning	Photographic Processing
Brewing	Industrial Plumbing

Boltaron 6200 is manufactured in the United States

CORROSION FORUM, *cont. . .*

316 STAINLESS STEEL
(Key on page 304)



Corrosion charts which accompany this article were prepared from "Corrosion Data Survey," G. A. Nelson, copyright Shell Development Co., Emeryville, Calif.

(Continued from page 302)

order, Type 316L, a low carbon modification of Type 316 (carbon = 0.03 max.) is available. As does Type 304L discussed in the last article, Type 316L resists harmful carbide precipitation from welding but should not be used if service temperatures are over 800 deg. F.

Even greater corrosion resistance can be obtained if Type 317 is used.

Typical Type 316 Applications

Sulfite pulp and paper production
Sulfurous, sulfuric, phosphoric, formic, acetic acids
Flue gases containing sulfur dioxide
Rapidogen aging of textile fibers
Distillation of formic acid
Hot concentrated lactic acid and naphthenic acid
Photographic equipment
Nitration reactions
Podbielniak counter-current solvent extractors
Aspirin manufacture (acetylization of salicylic acid)
Spray nozzles, flake drying belts in soap manufacture
High-pressure hydrolysis of fats and oils
Catalytic hydrogenization of fatty acids
Distillation, fractionating equipment
Heat exchangers, valves, pumps, mixing tanks
Manufacture of alkyd, acrylic, vinyl, and styrene resins
Reaction of phthalic anhydride with a polyhydric alcohol
Reactors for ammonia and sulfuric acid
Furnace roofs in the making of phosphoric acid

Representative Mechanical Properties

AISI Type	316	317
Sheet & strip, annealed		
Tensile strength, psi	90,000	90,000
Yield strength, psi	40,000	40,000
Elongation, % in 2 in	50	45
Rockwell hardness	B-85	B-85
Bars, annealed		
Tensile strength, psi	80,000	85,000
Yield strength, psi	30,000	40,000
Elongation, % in 2 in	60	50
Brinell hardness	150	160
Endurance limit, psi	38,000	......
Bars, (1") cold drawn		
Tensile strength, psi	90,000	......
Yield strength, psi	60,000	......
Elongation, % in 2 in	45	......
Brinell hardness	190	......
Endurance limit, psi	40,000	......

Reference—Steel Products Manual, Stainless & Heat Resisting Steels, Section 24, American Iron & Steel Institute.

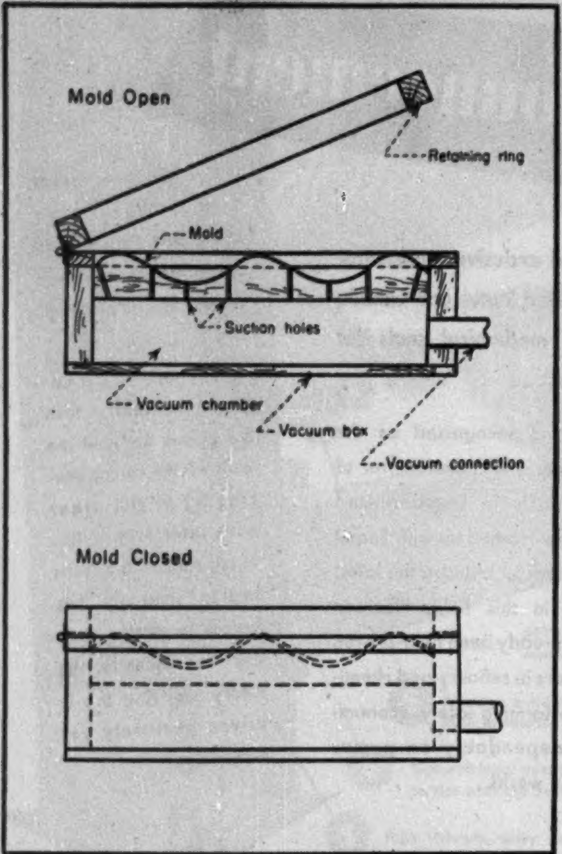
Type 317 is essentially a modification of Type 316 with more molybdenum added to meet more severe conditions. While useful wherever Type 316 finds application, Type 317 is especially recommended for textile equipment, sulfite digesters and the manufacture of inks and pharmaceuticals. It excels in places where freedom from contamination is necessary. At the present time due to emergency restrictions, Type 317 is not generally available.

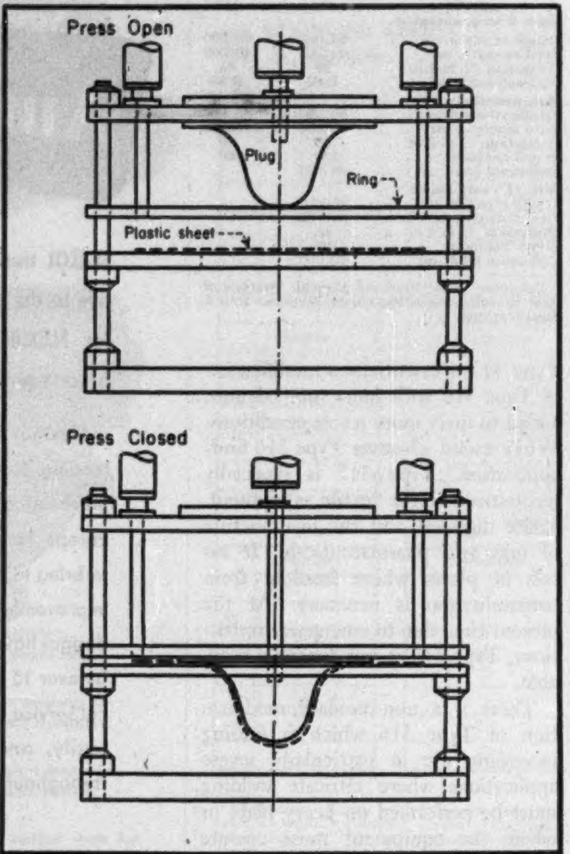
There is a non-standard modification of Type 316 which is finding increasing use in particularly severe applications where intricate welding must be performed on heavy plate or where the equipment must operate continuously at sensitizing temperatures. This modification—sometimes called Type 318—contains columbium as a stabilizing component in the alloy.

Corrosion data which accompany this article show that Type 316 is as good in almost all cases as Type 304 stainless. It is, in most instances, better. As in the previous article, it is best to use these charts for screening purposes only. Specific tests are the only reliable means for determining how a given alloy is going to stand up.

New Corrosion Glossary

The Inter Society Corrosion Committee, National Association of Corrosion Engineers, which now comprises 32 affiliated technical organizations interested in and doing corrosion mitigation, is compiling a glossary of corrosion terminology. Hugh P. Godard, Aluminum Laboratories, Ltd., Kingston, Ont., said two new members were added during the year ending March 15, 1953.





Proper Fabrication of Unplasticized PVC Equipment

To realize the inherent potentialities of plastic equipment, new fabrication techniques are being developed. Here's what to consider with unplasticized PVC.

GEORGE S. LAAFF

Selection of a plastic for use in chemical process equipment involves a careful balance of economic considerations with physical properties, corrosion resistance, and fabricating possibilities. More often than not, unplasticized polyvinyl chloride lends itself to a favorable balance of these various factors.

GEORGE S. LAAFF *is director of research and development, The Bolta Co., Lawrence, Mass. This article is based on material taken from the author's paper given before the spring meeting of the American Society of Mechanical Engineers, Columbus, Ohio, April 28, 1953.*

To reap the benefits obtainable from the selection of unplasticized PVC for chemical process equipment, the designer must be aware of the proper fabrication methods and the corresponding design kinks. He may be less familiar with these aspects than he is with the corrosion resistance and the physical properties of this material.

UNPLASTICIZED VS. RIGID PVC

First of all, the fabricator cannot hope to produce a product that will approach its theoretical possibilities unless the basic materials he has to work with are what they should be.

In this connection, the distinction between unplasticized and rigid polyvinyl chloride is important. Truly "unplasticized" PVC today is actually a purely theoretical phenomenon. The term "unplasticized" is used, however, as the term "rigid" PVC would open the entire field to the use of so-called processing aids and other types of modifiers without violating the basic terminology; whereas, the word "unplasticized" is much more specific and restricting. In a general way, commercial unplasticized PVC may be considered as a compound of substantially pure polyvinyl chloride resin in which only the minimum amount of stabilizer for processing stability is used. The optimum physical and chemical properties are obtained in unplasticized PVC.

"Rigid" PVC is the term applied to compounds which are substantially resin and stabilizer, to which modifying resins, fillers, and often small

Tests for Various Shapes of Unplasticized Polyvinyl Chloride

Extruded Rods and Bars

Brittleness—A hammer blow on material held firmly in a vise should not result in glass-like shattering.

Non-homogeneity—Acetone immersion for several days should result in swelling only, with no evidence of cracks, bubbles, separations, or porosity.

Extruded Pipes and Tubes

Brittleness—A hammer blow should not result in glass-like shattering. It should be possible to flare the end of the wall of the tube or pipe with pliers or wrench with no evidence of brittleness.

Non-homogeneity—Acetone immersion for several days should result in swelling only, with no evidence of cracks, bubbles, separations, or porosity.

Laminated Sheets

Brittleness (bending)—A strip ⅛ to ¼ in. thick of laminated sheet at room temperature should submit to repeated bending without cracking.

Brittleness (impact)—There should be no evidence of excessive brittleness on striking the sheet with a hammer.

Homogeneity—*Hammer blow and knife test* — Continuous delamination should not be possible with a hammer and chisel.

Steam-oven and hot-gun test—A sheet should not delaminate or blister when subjected to 320 deg. F. for 15 min. in steam oven or when subjected to blast from hot-air gun at approximately 500 deg. F.

Acetone test—A sheet should not show evidence of delamination after 1-2 hr. immersion in acetone at room temperature.

Molded Blocks

Brittleness—*Impact or hammer blow test*—same as for rods.

Non-homogeneity—*Acetone test*—same as for rods.

amounts of plasticizers have been added. These modifications are usually made to improve processing properties. The processing aids or modifiers added to the pure PVC resin, whether in polymerization or in subsequent processing, will reduce the intermolecular attractive forces of the polyvinyl chloride and thus will change the physical and chemical properties from those of pure resin. "Rigid" PVC will usually have lower physical and chemical properties than "unplasticized" PVC.

TESTS FOR UNPLASTICIZED PVC

One test to determine whether or not the processor of unplasticized PVC has excessively adulterated his product is the determination of the heat distortion point. This test by ASTM 648-48T will give values below 160 deg. F. if an unplasticized PVC has been excessively adulterated. Tensile values (ASTM 638-49T) falling below 8,000 psi. also indicate undesirable modifications.

Unplasticized PVC should meet a group of other tests which will establish just how well the basic material has been processed (see table).

WELDING

Method of fabrication offering the

Forms Available

Sheets, 1/32 in. through 1 in.
Tubing and pipe, ¼ in. through 6 in.
Bar stock, round and hexagonal
Solid blocks for heavy cross sections
Welding rod
Molding compounds for transfer molding

widest range of applications and extending the possible size of installations almost infinitely is that of hot-gas welding.

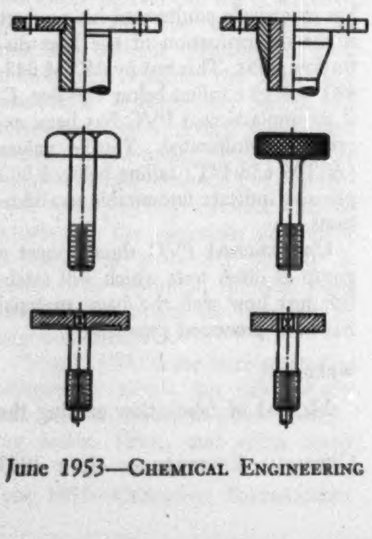
The raw stock which the fabricator uses must first of all be capable of a good weld. Some high molecular weight resins cannot be welded unless the resin and the welding spline have been modified, although such changes are to the detriment of other equally important properties. Use of such PVC resins is to be avoided.

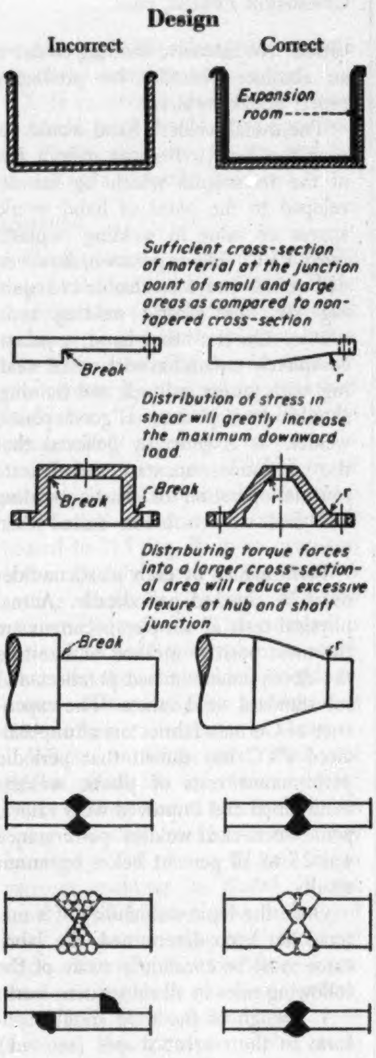
Much of the art of early hot-gas welding has now been resolved into widely accepted concepts. Present day hot-gas welding torch consists of a coiled tube, heated by a gas flame or a resistance coil, through which passes the welding gas, usually compressed air or an inert gas such as nitrogen. By varying the size of the flame or the resistance and/or the volume of the inert gas, the temperature of the issuing hot gases may be varied over a wide range. For welding unplasticized PVC, temperatures of 475-550 deg. F. are normally used.

Welding of unplasticized PVC is essentially the same as the electric-arc welding of metals in regard to the preparation of the pieces to be welded. Main difference is in the type of joining which takes place. While complete fusion of the rod and stock takes place in metal welding, with a thermoplastic such as unplasticized PVC a simple

Design

Incorrect | Correct





bonding takes place between the contacting surfaces of the rod and stock. A slight pressure applied to the rod forces the two melted surfaces together, producing a homogeneous weld.

To obtain uniformly good welding, the area to be welded as well as the rod must be sufficiently preheated by the hot-gas jet before being forced into the weld bed. Too little heat results in a poor bond while overheating may cause the material to decompose.

When proper techniques are followed, weld values may be obtained which will normally be 85 percent of the tensile value of the base material. Often the tensile strength of the weld is greater than the sheet. The impact strength in the vicinity of the weld is reduced.

Proper welding must be considered the most important element of fabri-

cation. An intensive training course is an absolute necessity for producing expert plastic welders.

The metal welder's hand would appear too heavy. Perhaps only a few of the techniques which he has developed to the point of habit would appear of value in welding unplasticized PVC. His experience, however, will quickly prove invaluable in acquiring the new plastic welding techniques. On the other hand, a person completely unfamiliar with metal welding, with proper aptitude and training, should develop into a good plastic welder. It is generally believed that the continuous, accurate and delicate routine operation of plastic welding will find women better suited than men.

Performance of each plastic welder must be checked periodically. Actual physical tests of sample specimens are the most positive method of arresting the development of bad practices and sub-standard weld values. The experience of German fabricators of unplasticized PVC has shown that periodic performance tests of plastic welders maintained and improved weld values, while unchecked welders' performance was 25 to 50 percent below optimum results.

Once the basic weldability of a material has been determined, the fabricator must be constantly aware of the following rules in all subsequent work:

1. Design of the weld should conform to the correct shapes (see cut) incorporating the conceptions of proper stress distribution.

2. Surfaces to be welded should be clean and smooth but not polished.

3. Amount of heat applied by the welding gun should be uniform along the length of the weld, and it must be sufficient to effect melting of the rod surface and softening of the rod and melting of the weld-bed surfaces without localized decomposition.

4. A uniform pressure must be maintained on the welding rod at right angles to the plane of the weld to insure intimate contact between the melted surfaces of the rod and the bed.

5. Utmost uniformity should be sought in a weld. Waviness along the weld, and elongation of the rod must be avoided.

6. Fewest rods possible should be laid in a single bed because each weld increases the danger for strains and

overheating with subsequent weakening of the complete weld.

7. If an error is made in the course of a weld, work should be stopped and the faulty area scraped out and replaced by a properly laid bead.

MOLDING

Unplasticized polyvinyl chloride may be shaped in fabrication by slight modifications of the common molding techniques used in the plastics industry. Shallow forming may be done on thin sheets by the vacuum method illustrated. The molds may be made inexpensively of wood, masonite or aluminum. A vacuum of 17-25 in. of mercury is sufficient to mold sheets up to $\frac{1}{8}$ in. thickness. The material is heated to 215 deg. F. in an oven and is then quickly placed on the mold. A sealing frame is lowered, and the vacuum is applied. This suction is maintained until the stock cools somewhat, and then the molded piece is removed. After complete cooling, it is trimmed on a saw, router or shear.

Where moldings are made of thicker materials or where deeper draws or sharp curves are required, the "plug and ring" mold (see cut) may be used. The sheet, heated as in vacuum molding, is placed in the mold. The forming plug is lowered until the pressure ring grips the sheet edges. The plug then continues downward pressing sheet into mold contour.

For intricate shapes and heavy cross-sections, the transfer molding technique is followed. Pipe fittings and similar parts are produced by this method. Weighed charges of unplasticized polyvinyl chloride are heated and then placed in the transfer pot or cylinder. The transfer piston moves downward under pressure and forces the hot materials through an orifice into the steel mold itself. The mold is then cooled and the piece is removed. Because of high mold costs, this method of fabrication is usually used in making those shapes which are complex and which are used in great quantities.

MACHINING

Unplasticized PVC may readily be machined on the common wood and metal working tools. There are some slight modifications and precautions which must be observed, but the adaptation of skills and tools to shaping this material is not difficult. Saws should have little or no set. *(Cont'd)*

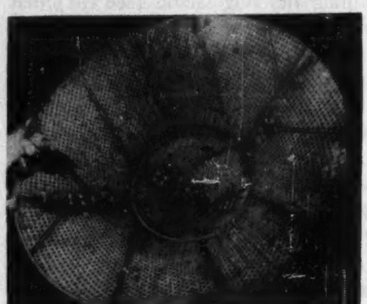
CORROSION FORUM, cont. . .

This material may be sawed, cut, turned, milled, bored, punched, and polished. Cutting speeds are similar to those used for light metals. Unplasticized PVC is a poor heat conductor, however, and efficient cooling must be provided to prevent localized melting of the stock.

STRESS DISTRIBUTION

In the shaping of parts, the fabricator must avoid sudden contour transitions and notches. Heavier cross sections than would be normal with other structural materials must be used in regions of high stress. Design is done with a view toward distributing predictable stresses over wider areas (see cuts). The concentration of stresses at a point must be avoided.

With regard to assembly, since the material lends itself so well to shaping by the normal wood and metal tools, fine workmanship should be expected. Tolerances can be held quite close, and there should be no evidences of cracks, gouges or tool marks on finished fabrications.



Enter Hastelloy F

Hastelloy alloy F is a new nickel, molybdenum, chromium, iron alloy developed as the result of a long-range research program. This alloy will withstand the corrosive effects of oxidizing and reducing acids; it can handle both acid and alkaline solutions; it will resist pitting and stress-corrosion cracking in chloride solutions; and it has good hot-working characteristics.

Hastelloy alloy F has not been fully tested under all the many and varied conditions that exist in the complicated field of corrosion. Its full potential will not be known until it has had a chance to compete against current alloys in the metals, chemicals, petroleum and other industries.

Tests made so far with this new alloy have been encouraging. One bears mentioning here. The A. O. Smith Corp. was looking for an alloy to be used as a lining in the dome of a paper and pulp digester. None of the corrosion-resistant alloys available at that time was satisfactory. Hastelloy alloy F was tried—because it was new. No one expected it to work. But it did—and so successfully that it is now the standard material of construction for that application.

More tests will be made—and more uses for this new alloy will be found.

HOW ALLOY F WAS DEVELOPED

Development of Hastelloy alloy F stemmed from a research program aimed at producing an alloy intermediate in price, corrosion resistance, and workability, between the austenitic stainless steels and the nickel-molybdenum alloys. An effort was made to produce an alloy that combined the excellent resistance of the austenitic stainless steels to strong oxidizing conditions, and the unusual ability of the nickel-molybdenum alloys to withstand reducing solutions. Approximately 250 alloys were tested during the research program.

CORROSION TESTING

Corrosion portion of the program consisted of testing the alloys in 65 percent nitric acid at the boiling point, a strongly oxidizing acid; boiling 10 percent sulphuric acid, a typical reducing acid solution; and a 10 percent solution of aerated hydrochloric acid, a strongly reducing acid. Resistance to pitting was evaluated by testing the alloys, at room temperature, in a 5 percent ferric chloride solution containing 10 percent sodium chloride. A few tests were conducted in wet chlorine at room temperature and in hypochlorite bleach solutions.

As the tests progressed, it became apparent that a compromise had to be made in order to obtain a balanced chemical composition. Nickel and molybdenum were considered essential ingredients if the alloy was to resist reducing conditions. However, these elements reduce the effectiveness of an alloy in oxidizing solutions. Chromium, an essential element for handling oxidizing solutions, lessens the resistance of an alloy in reducing conditions. Chromium and molybdenum were both needed to resist the pitting action in the ferric chloride

CORROSION FORUM, *cont.* . .

solutions. Further improvement in pit resistance was gained when small amounts of columbium and tantalum were introduced into the alloys.

ESSENTIAL ELEMENTS

Further experiments confirmed the fact that a complex solid solution of nickel, chromium, molybdenum and iron was the answer to the problem. Alloys of this type may be susceptible to precipitation when subjected to certain critical temperature ranges. Columbium and tantalum lessen the corrosion resulting from precipitation, but do not render an alloy completely free from corrosion attacks over prolonged periods of exposure.

None of the alloys tested would resist wet chlorine satisfactorily. In general, the alloys that resisted pitting in ferric chloride solutions were also resistant to cold calcium hypochlorite solutions containing 10 percent available chlorine.

The test program continued until all but one alloy had been eliminated —Hastelloy alloy F.

Summer Courses on Plastics

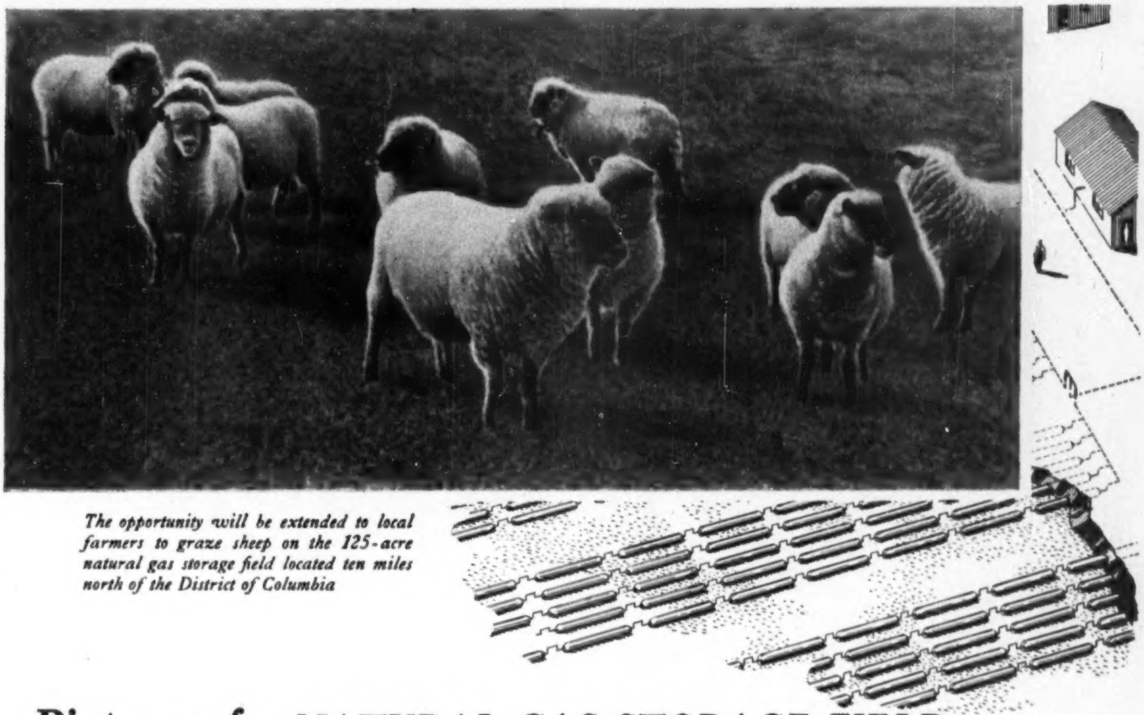
In response to numerous requests by corrosion engineers and maintenance men, Atlas Mineral Products Co. has established courses of instruction on plastic materials of construction. In previous years, these courses have been presented impromptu to visiting corrosion engineers from the larger chemical and steel companies. Present plans are to invite all interested corrosion engineers or maintenance men.

These subjects will be covered:

Basic fundamentals of plant design, properties of plastics and ceramic materials used for chemical resistant equipment, protective coatings, rubber and plastic linings, chemical resistant cements, plastic pipe, all plastic structures, pipe jointing materials, floor and tank construction, chemical process equipment, waste disposal lines and sewer construction, corrosion resistance of specific materials, economic consideration in corrosion resistant construction, testing methods and application of corrosion resistant plastic materials.

Those interested in attending these courses should write to Joseph A. Snook, vice president, Atlas Mineral Products Co., Mertztown, Penna.

—End



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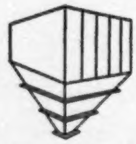
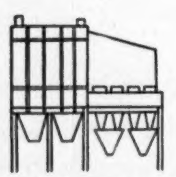
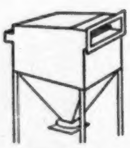
VAN TONGEREN CYCLONE



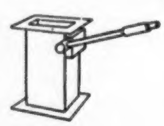
'SF' ELECTRIC PRECIPITATOR



PRECIPITATOR—CYCLONE COMBINATION



TYPE 'LR' COLLECTOR



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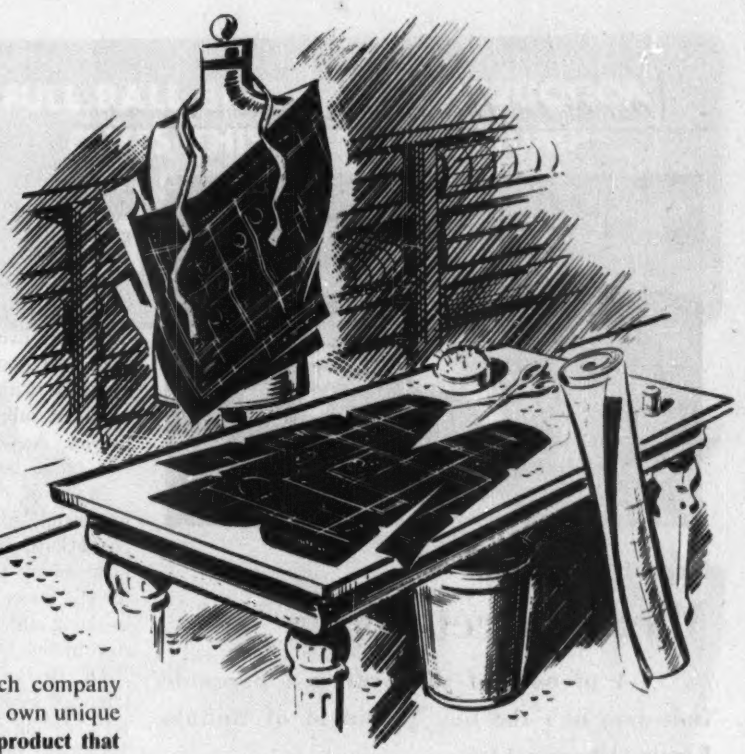

Names in the News Edited by Frances Arne

Man of the Month:

Max E. Bretschger

A pioneer of the hydrogen peroxide industry, he's the new president of Buffalo Electro-Chemical Co.

Max Bretschger has seen hydrogen peroxide develop from a very humble place to an enviable position in the chemical industry. He himself has played a considerable part in this development.

Since joining Buffalo Electro-Chemical Co. shortly after its founding in 1925, Dr. Bretschger has supervised the introduction of the following "firsts" to the industry: the first aluminum tank car for shipping concentrated hydrogen peroxide in 1931; the installation of the first Ignitron mercury rectifier in the chemical industry of this country in 1937; in 1944 the development of a process for making 90 percent hydrogen peroxide; and in 1947 the erection of the first mechanical rectifier this side of the ocean.

There's nothing Dr. Bretschger enjoys more than talking shop. His wife, Julie, has even been driven to laying down a strict ban on any talk about peroxide at social gatherings at their home. To make matters worse, both Bretschger sons, Alfred and Paul, are in the peroxide industry.

Perhaps Dr. Bretschger's biggest extra-professional interest is his five grandchildren. One, 4-yr.-old Teddy who lives next door, has a habit of coming over for a second breakfast with his grandfather. The five of them make excellent subjects for Dr. Bretschger's color pictures and movies. A special hobby, the camera also goes along with him on all business or pleasure trips.

Many of these pleasure trips are to Switzerland, his homeland. About every other year he and Mrs. Bretschger go back to visit relatives and friends and return with a great many pictures of the glorious scenery. His love for the Swiss mountains is evident in an abiding interest in skiing and climbing. To this day he maintains membership in the Swiss Alpine Club.

Dr. Bretschger was born in Switzerland in 1884. He attended Federal Institute of Technology at Zurich and after serving for two years as an assistant to Prof. F. P. Treadwell, he received his Ph.D. from the University of Zurich in 1910. The succeeding years he spent in Austria, Italy and Germany working in laboratory and production of various chemical industries. In 1919 he associated with Electrochemical Works Francks at Aarau, Switzerland, where he became production manager.

In 1925 Charles A. Buerk founded Buffalo Electro-Chemical Co. and, looking for an authority on the manufacture of hydrogen peroxide, induced Dr. Bretschger to come to the United States. So in 1926 Dr. Bretschger moved to Buffalo to become manager in charge of production and development. Later on he became vice president of the company which position he held until the death of Mr. Buerk in November 1952. Shortly after, the board of directors elected him unanimously to succeed Mr. Buerk as president of the company.

C. L. Norton, Jr. From technical director to executive assistant in charge of all development and engineering activities, Babcock & Wilcox Co., New York.

Wayne Kuhn. President, Commercial Chemical Development Assn. Manager, technical and research division, the Texas Co. New president-elect: **Nolan Sommer,** supervisor, new product development, American Cyanamid Co.

N. H. Marsh. Chief chemist, American Cyanamid Co.'s nitrogen chemicals plant under construction near New Orleans. Has been co-ordinator of a special project at the company's Stamford Research Laboratories, Stamford, Conn. With the company since 1945. Doctorate in chemistry from Rice Institute. Chief analysts at the New Orleans plant: **F. W. Mitchell, Jr.** who has been a senior research chemist for General Aniline & Film Corp., Easton, Pa. Doctorate in organic chemistry from California Institute of Technology.

Harold J. Dawe. From director of product development to technical director, Acheson Colloids Co., Port Huron, Mich. Doctorate from the University of Michigan. New production manager: **John W. Shier** who has been Acheson plant engineer since 1949. Previously, chemical engineer for Heyden Chemical Co. in Detroit. Chemical engineering graduate of Wayne University. New supervisor of the product development laboratory: **Earl L. Youse.** Employers before joining Acheson last year: General Aniline and Film Corp.; Hercules Powder Co.

W. H. Tonn, Jr. To act in a consulting capacity on all phases of chemical development and research for John J. Harte Co. Houston. His industrial-academic experiences: research technologist Shell Chemical; senior

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Bulletin 976-D

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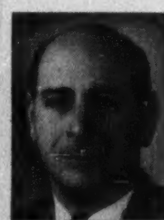
chemical engineer Sinclair Rubber; associate professor of chemical engineering University of Oklahoma; chief chemical engineer Rohm and Haas Co.; assistant director of research, plastics project, MIT.



Osborne Bezanson

Henry H. Bitler

Osborne Bezanson. From president to chairman of the board, Chemstrand Corp., Decatur, Ala. Previous to assuming the Chemstrand presidency in 1950 he was a vice president and officer of Monsanto. New president of Chemstrand: **Henry H. Bitler** who has been with American Viscose for 33 years most recently as general manager of acetate and vinyon manufacturing.

Frank B. Ralston. Purchasing agent of Carlisle Chemical Works, Inc., Reading, Ohio. Has been purchasing agent for Owens Corning Fiberglass Corp. of Newark, Ohio, for 12 years.

Edwin M. Haun. Project supervisor in Monsanto's overseas division. Has been a member of the development department of the company's phosphate division since 1950. Joined the company in 1941. Graduate of the University of Illinois.

Howard J. Lucas. Recipient of the Scientific Apparatus Makers Award in Chemical Education presented by ACS. Member of the California Institute of Technology faculty for 40 years.

John M. Deming. Group leader in charge of soils research at the Creve Coeur laboratories of Monsanto's organic chemicals division. With the company since 1951. Doctorate from Purdue.

Elaine Rosenbaum. Associated with the research and development division of Wyandotte Chemicals Corp., Wyandotte, Mich. To work

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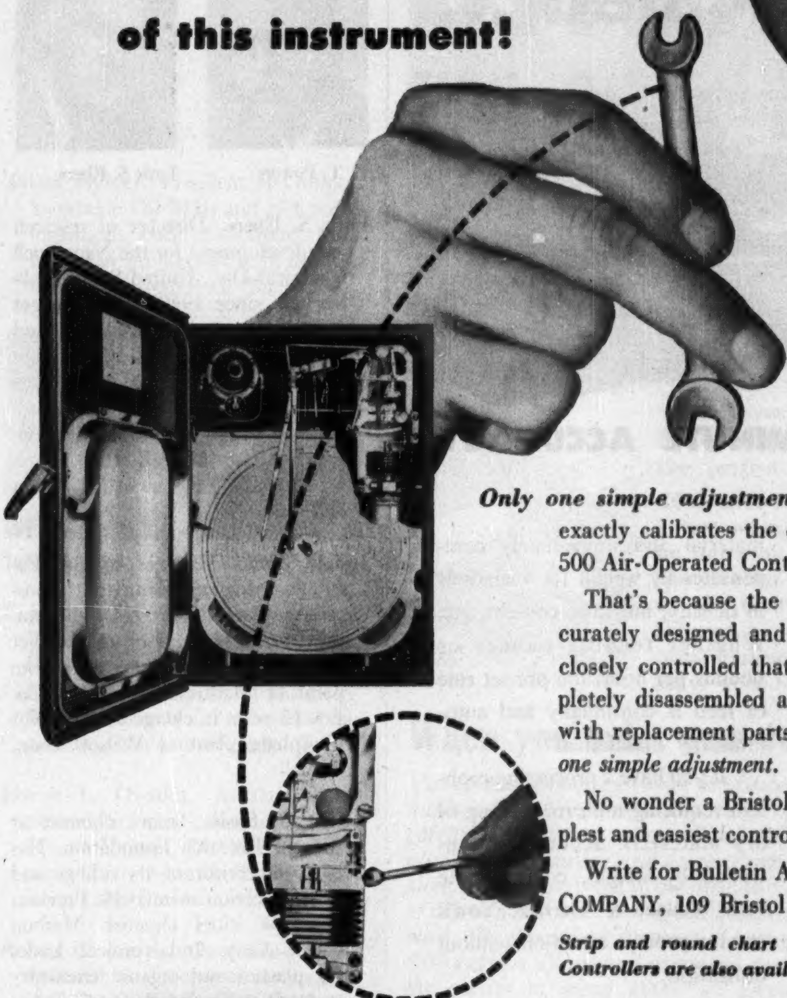

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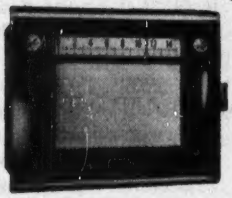

BRISTOL

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in the contract research department on problems of interest to the Armed Forces.

E. T. Powers. Director of the newly organized development department of Celanese Corp. of America. Has been associated with the administration of the chemical division of the company since 1945.


E. T. Powers


Earle S. Ebers

Earle S. Ebers. Director of research and development for the Naugatuck Chemical Div., United States Rubber Co. since 1949, sales manager of the company's Kralastic and Vibrin resins. Joined U. S. Rubber as a research chemist in 1937. Doctorate in chemistry from Harvard. From manager of plastics development to assistant director of research and development: **D. Lorin Schoene.**

Josiah Work. Manager of the Pocatello, Idaho, elemental phosphorus plant of Westvaco Chemical Div. Has been plant manager of the new Houston phospahte plant of Mathieson Chemical Co. For 12 years in charge of the TVA phosphate plant at Wilson Dam, Tenn.

Alfred G. Susie. Senior chemist at Armour Research Foundation. Has been supervisor of its rubber and plastics section since 1949. Previous positions: chief chemist, Marbon Corp., Gary, Ind.; project leader for plastics and organic chemistry research at Esselen Research Corp., Boston; chemist for Sun Oil Co., Toledo.

M. Merlub-Sobel. Project director and technical advisor in the chemistry department, Horizons Inc., Princeton, N. J. Has been associate professor of chemical engineering and metallurgy at the Hebrew Institute of Technology in Haifa,

Israel. Earlier positions: technical manager, Palestine Potash Ltd., Jerusalem; director of research, Virginia-Carolina Chemical Corp.

Otto Kay. Member of the staff of Sam Tour & Co., New York research, development and testing firm. Previously a technical consultant in New York specializing in inorganic industrial chemistry. Other employers: Armour Research Foundation; Solvay Process Div. of Allied Chemical and Dye Corp. Studied at the University of Munich.

Henry Tovey. Senior literature chemist in charge of the Washington, D. C., literature research branch of Bjorksten Research Laboratories.

Julian Saphier. President of Gulfport Vegetable Oil Mills and of Landon Chemicals, both of Gulfport, Miss. Has been manager of resin development, U. S. Industrial Chemicals.

Julian Saphier

F. H. Fritz, Jr.

F. Herman Fritz, Jr. Transferred from Wilmington to Akron to manage Du Pont's rubber laboratory there. A former employer: Firestone Industrial Products Co. Chemical engineering graduate of Bucknell.

Joseph L. Owades. Assistant chief chemist, Schwarz Laboratories, Inc., Mount Vernon, N. Y. Has been engaged in research for Fleischmann Laboratories.

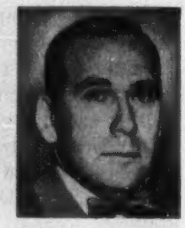
Robert G. Larsen. On a two-year assignment as director of research at Shell Oil Co.'s Martinez, Calif., refinery. Acting head of the lubricants and fuels department, Shell Development Co., Emeryville, Calif., during his absence: **William F. Ross** who has been assistant department.

Walter R. Hibbard, Jr. Manager of the newly established alloy studies section in the General Electric Re-

NAMES IN THE NEWS, *cont.* . .

search Laboratory's metallurgy research department. Has been assistant manager of the laboratory's materials and processes section.

Ernest E. Lyder



Nathan Shlechter

E. E. Lyder. Consultant on refinery and petrochemical plant engineering and operation, Bechtel Corp.'s industrial division at Los Angeles. Recently retired as general manager of the El Segundo refinery of Standard Oil of California. New Bechtel process design engineer in the fields of ,petroleum refining and petrochemistry: **Nathan Shlechter.**

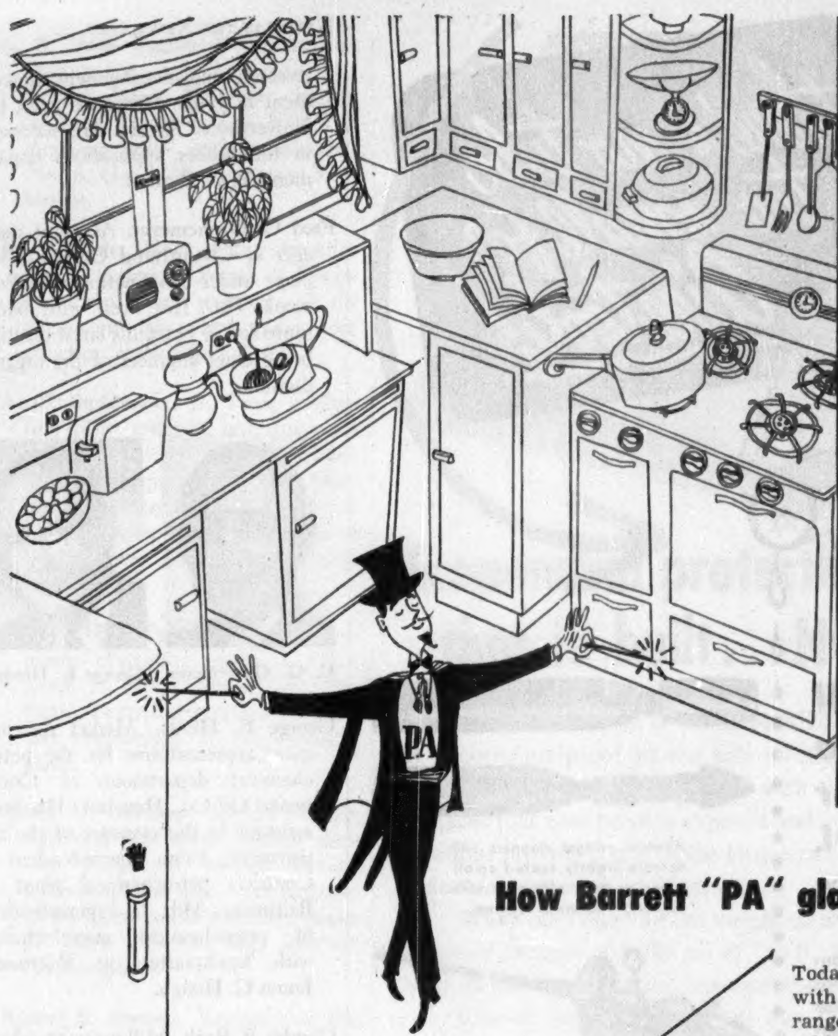
Clark B. Carpenter. Retired head of the metallurgy department and dean of the graduate school at the Colorado School of Mines, Golden, Colo. Has been on the faculty since 1920, a full professor since 1936.

Wingate A. Lambertson. Professor and research associate, Institute of Silicate Chemistry and Related Sciences, University of Toledo. Has been engaged in basic research of ceramic materials for nuclear reactors with the Argonne National Laboratory. From assistant professor of chemistry to assistant to the director of the institute: **Arthur H. Black.**

William Gebrian. Chemical engineer, process study group, Hooker Electrochemical Co.

John E. Barry. New member of the staff of the Witco Laboratory in Amerillo, Tex. Formerly with U. S. Industrial Chemicals Co.

Leland M. White. Assistant director of the research and development department, U. S. Rubber Co. Has been head of the rubber applications department at the company's Passaic, N. J., general laboratories since 1947. Joined the company's



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- "ELASTEX" DCHP Plasticizer
- "ELASTEX" 50-B* Plasticizer
- Phenolic Resins
- Urea Resins
- Niacin (Nicotinic Acid)
- Isonicotinic Acid
- Pyridines
- Picolines
- Quinoline
- Lutidines
- Tar Acid Oils
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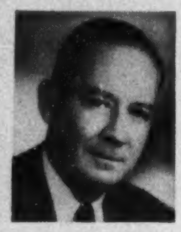
research and development department in 1940. Doctorate from the University of Kansas. His successor in the rubber applications department: **B. C. Barton.**

Fred G. Gronemeyer. Assistant manager of Chemstrand Corp.'s nylon plant under construction near Pensacola Fla. Has been with Monsanto for 22 years, his latest position being chief engineer of the organic division.

F. G. Gronemeyer — George E. Hinds

George E. Hinds. Market development representative for the petrochemical department of Continental Oil Co., Houston. Has been assistant to the manager of the department. From superintendent of Conoco's petrochemical plant at Baltimore, Md., to superintendent of petrochemical manufacturing with headquarters at Baltimore: **James G. Hough.**

Charles E. Roth. Mill superintendent, Jesup Div., Rayonier Inc. Has been pulp mill superintendent with Riegel Carolina Corp., Acme, N. C. Chemical engineering graduate of Ohio State; studied at the Institute of Paper Chemistry, Appleton, Wis.

William P. Liljestrom. Chemical specialist for the Pacific Coast region, Reynolds Metals Co., Louisville, Ky. Has been with Filtrol Corp., Los Angeles, since 1946 as a plant engineer; engineer in charge of application, catalyst research; technical service sales engineer. Chemical engineering graduate of Notre Dame.

W. E. Kennel. Section leader, chemical products division at Standard Oil's Whiting, Ind., research laboratories. New group leaders in the same division: **V. J. O'Brien, Jr.,** and **K. C. Peterson.**

A. E. Bost. President of Chemical Process Co., San Francisco, succeeding **James D. Dole,** named chairman of the board. New vice president and general manager: **Paul A. Gross.** New treasurer: **V. J. Moran.**

W. A. Gale. Head of the executive staff at American Potash & Chemical Corp.'s new research and development laboratory under construction at Whittier, Calif.

A. C. Burkholder, Jr. From production plant assistant superintendent to superintendent in the light hydrocarbon department, Dow Chemical Co., Freeport, Tex. With the company nine years. Graduate of Southwestern State Teachers College.

John R. Hill. Transferred to the economic evaluation group of Ethyl Corp. in Baton Rouge, La. Formerly chemical engineer in research and engineering at the Houston plant.

James N. Garrison. Special projects engineer, petroleum refinery division, Arthur G. McKee & Co., Cleveland. Has been chief engineer of the division. His successor: **James C. Baird** who has been assistant chief engineer.

Robert B. Sosman. Recipient of the sixth annual Albert Victor Bleininger Memorial Award for distinguished achievement in the field of ceramics. Professor on the staff of the school of ceramics of Rutgers University, New Brunswick, N. J. From 1928 to 1947 on the staff of the research laboratory of the U. S. Steel Co. in Kearny, N. J.

E. D. Powers. President, director and member of the executive committee, Chemical Construction Corp. He continues as vice president and director of American Cyanamid.

OBITUARIES

Louis Goldman, 44, supervising chemist of the boiler water service section, Bureau of Mines, College Park, Md., died March 4.

William W. Skinner, 78, former chief of the Bureau of Agricultural and Industrial Chemistry, Dept. of Agri-

NAMES IN THE NEWS, *cont. . .*

culture, died in Olney, Md., March 10.

E. B. Hart, chairman emeritus, biochemistry department, University of Wisconsin, died in Madison March 11.

James W. McBain, 70, who played a leading role in developing detergents, died in Palo Alto, Calif., March 12. Dr. McBain left Stanford University where he was professor emeritus of chemistry in 1947 and two years later became the first director of India's National Chemical Laboratory. Just before his death he was working as consultant on Stanford Research Institute's current study of the structure of liquid surfaces.

Paul Schlosser, 59, research manager of Rayonier Inc., died March 12.

Emil C. Barell, 79, formerly international president of F. Hoffman-La Roche and Co., Ltd., died at his home in Basle, Switzerland on March 17.

Andrew J. Schilling, 91, founder of the Idaho Soap Co. and its successor, Western Chemical Co., died at his home in Boise, Idaho, March 19.

James R. Withrow, 74, Consulting technologist and minerologist for Wright Field Co., died March 20. Until his retirement a few years ago he was chairman and professor of the chemical engineering department at Ohio State.

Frederick D. Schreiber, 62 manager of the coal chemicals division of Pittsburgh Coke & Chemical Co., died in Ocala, Fla., March 22.

Walter E. Blair, assistant to the president of Solvay Process Div., died in Sarasota, Fla., March 23.

Leslie W. Auston, 58, director of research at Kaiser Permanente plant near Monte Vista, Calif., died at San Jose, Calif., March 28.

Carl E. Johnson, 69, one of the founders and chairman of the board of Sterling Electric Motors, Inc., died at his home in San Marino, Calif., March 25.

Sulphur

Molten Sulphur flowing into the storage vat

Thousands of tons mined daily, but where does it all go?

Look around you in any grocery store and what do you see—canned goods of all kinds! Soups, vegetables, fruits, berries! Believe it or not, you're looking at merchandise that consumed a lot of Sulphur in the making.

Tin cans are made of tin plate. Tin plate is made of sheet steel. Sheet steel is made with the help of sulphuric acid—pickling, as they call it, the process that removes scale preparatory to plating. In 1951, the sheet division of our great iron and steel industry is estimated to have consumed 140,000 long tons of Sulphur in the form of sulphuric acid. That in itself makes quite a dent in our supplies of Sulphur. Add to this almost as much more for treating wire rod, plate, strip, bars, etc., and you can see that to make finished steel, regardless of form, the iron and steel industry must use lots of Sulphur in the form of sulphuric acid.

Right here is an excellent example of the interdependence of all of our industries. To produce steel requires a lot of Sulphur. To produce Sulphur and other mined products requires a lot of steel. This interdependence of industries is one of the country's sources of strength.

Texas Gulf Sulphur Co.

75 East 45th Street, New York 17, N. Y.

Mines: Newgulf and Moss Bluff, Texas

Industrial Notes

NEW SERVICES

Battelle Institute, Columbus, Ohio, has established a technological information service. It will be tailored to meet individual needs and will include the preparation of bibliographies, and coding and classification systems. Where required, the institute will undertake development of information processing equipment.

Radioactive Product, Inc., Detroit, is now offering encapsulation services on radioactive sources. The firm is now handling Cobalt 60 sources for industrial radiography of castings and weldments as well as other types of radioactivity. Capsules and carrying containers can be supplied by either the manufacturer or by the customer.

NEW REPRESENTATIVES

American Smelting and Refining Co. has appointed the Troy Belting and Supply Co., Troy, N. Y., as distributor in eastern New York and western Vermont for the continuous-cast bronze products of its Perth Amboy plant, Barber, N. J.

Fairfield Engineering Co., Marion, Ohio, has appointed J. D. Wilson Co., Milwaukee, as representative in Wisconsin of its Fairfield Contract Div. which designs, constructs and services coal and ash handling equipment and bulk conveying and storage installations.

Copes-Vulcan Div., Erie, Pa., has appointed Power Economy, Inc., St. Louis, Mo., as representative for its products which include boiler controls and soot blowers of all types.

Acme-Hardesty Co., New York, has appointed Hukill Chemical Corp., Cleveland, to handle a complete line of fatty acids, hydrogenated oils and glycerine in the northern Ohio territory.

Heli-Coil Corp., Danbury, Conn., manufacturer of screw thread inserts of stainless steel wire for industry, has established the Resources & Facilities• Corp. as exclusive licensee under Heli-Coil patents throughout the world, save for the western hemisphere.

American Flexible Coupling Co., Erie, Pa., has appointed the Paddon Co., Youngstown, Ohio, as sales engineers in eastern Ohio and western Pennsylvania.

Continental Equipment Co., Coraopolis, Pa. manufacturers of butterfly valves, has appointed the Peerless Bros. Agencies, Ltd., Vancouver, B. C., as Canadian representatives.

NEW FACILITIES

Westinghouse Electric Corp., Pittsburgh, Pa.—A San Francisco branch office headed by Harold G. Rethmeyer.

National Adhesives Div., National Starch Products Inc.—Additional capacity for the production of polyvinyl acetate at its Plainfield, N. J., plant.

Merritt-Chapman & Scott Overseas, Inc.—New offices in the Empire State Bldg., New York. The company specializes in the planning and development of construction operations abroad.

Hyster Co., Portland, Ore.—A New York dealership and national accounts headquarters located in Long Island City, N. Y.

Metro-Atlantic, Inc.—Southern headquarters in Greenville, S. C.

Automatic Switch Co., Orange, N. J.—A factory branch in Los Angeles to stock a variety of solenoid valves and electromagnetic control and to function as West Coast service center.

Charles H. Lilly Co.—Anhydrous ammonia storage facilities at Albany, Ore., to serve the Willamette Valley agricultural area.

General Petroleum Co.—A $500,000 administration building (see cut) at its Torrance, Calif., refinery. The new structure houses 135 engineering and administrative personnel in its 32,500 sq. ft.

Carbide and Carbon Chemicals Co.—A district sales office for its textile fibers department in Chelmsford, Mass., to provide the textile industry in New England with assistance in the use of Dynel.

Air Products, Inc.—The first unit of a research laboratory. It is the first of six which will eventually comprise the company's research department. Air Products makes oxygen-nitrogen generators and equipment employing extremely low temperatures used in the chemical and petroleum industries.

Dow Chemical Co., Midland, Mich.—A tank farm under construction at Bayonne, N. J., for storage of 3.25 million gal. of such chemicals as caustic soda, carbon tetrachloride, perchloroethylene, methylene chloride, glycols and chloroform.

Pennsylvania Falk Chemical Co.—General sales offices in Pittsburgh, Pa. This step is the result of increased production of its resins for the protective coating field.

University of Puerto Rico's agricultural experiment station—A pilot plant to assist rum manufacturers in solving their technical problems. The distilling unit of the plant was designed and installed by Arthur D. Little.

Reichhold Chemicals, Inc.—A manufacturing division at Ballardvale, Mass., to produce its extensive line of synthetic resins and basic indus-

News about

UNICHROME
Trade Mark

COATINGS for METALS

Metallic .... Organic .... Decorative .... Protective

Using an Engineering Approach in Plant Painting

Cuts Maintenance Costs—Corrosion, too

Porosity no problem with Plastisol protection

In a recent test of many coatings for use in refrigeration equipment, only a Unichrome Plastisol Coating withstood 1500 hours of water immersion. All other coatings tested by the user failed because of porosity.

This case emphasizes why Unichrome Plastisols, which build up a film thickness of from 3 mils to 3/16-inch as desired, give such extraordinary protection to ordinary metals in contact with a wide variety of corrosives. The chemicals don't penetrate this heavy duty coating to attack the metal. Nor do they attack the coating itself since it is a vinyl formulation.

If *you* need an exceptional protective material for processing equipment, investigate a Unichrome Plastisol Compound.

Improved phenolic-type lining for drums

Phenolic coatings are the dependable "workhorse" of the drum lining industry. They have long been favored by packaging engineers for use in steel containers to protect the package from corrosion and the contents from contamination.

Unichrome Series B-124 Linings have been acknowledged by many users to be outstanding improvements in this type of material. They bake into extremely tough and durable linings that have excellent adhesion and unusual ability to withstand strong acids, oils, food chemicals, vinegar, wetting agents. Solvents such as benzene and ketones also have no effect on B-124 linings.

Other linings also available for other products. Write for data, and for information on manufacturers and reconditioners supplying drums with Unichrome Drum Linings.

Coatings have definitely become important materials of construction to the chemical or corrosion engineer. With many types of coating materials available to meet unusual requirements, no longer is surface protection being classed as merely another paint job. Instead, many plants are thinking of maintenance painting as an engineering problem, to be solved by an engineering approach.

Such an approach can make a big difference in results—both in longer lasting equipment and more durable paint jobs.

AN ENGINEERED PAINTING PROGRAM

Engineering a solution to a painting problem means devoting proper attention to surface preparation for the coatings which are to be applied. It means specifying a system or combination of coatings devised for the service conditions encountered.

ADEQUATE SURFACE PREPARATION

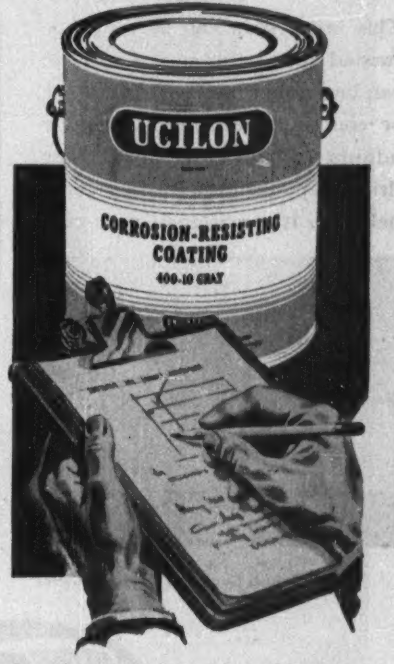
Generally, the tougher the corrosion problem, the more attention the surface needs. Sometimes this includes careful mechanical preparation. Experience has shown that, when required, one of the most important steps is also priming. This contributes to better adhesion of subsequent top coats. It adds extra corrosion resistance and minimizes undercutting of the protective film in the event of a break in its continuity.

Ucilon Coating Systems include proved materials for use in priming wherever individual applications require them. These include chromate-type primers, wash primers, intercoats.

CORROSION PROBLEMS SOLVED

Systems of Ucilon Coatings form effective barriers to a hundred and one tough, corrosive conditions. Many such systems are available to permit the engineer to specify a material that protects against intermittent or continuous contact with acids, alkalies, salt solutions, alcohols, moisture, oils, chemical compounds and other products.

Protection provided by Ucilon Coatings is based on vinyl, chlorinated rubber, phenolic or fish oil formulations and the degrees of chemical resistance that such materials possess. Some coatings require baking. Most dry by solvent evaporation or by oxidation.



"AN OUNCE OF PREVENTION"

Preventive maintenance was always a good idea. Today it can be considered virtually vital in order to end needless corrosion of equipment and avoid the production delays, costly downtime and replacement headaches that such damage entails. Ucilon Coatings Systems can help you achieve longer lasting protection at lower cost and make your preventive maintenance more effective.

Be sure to look up the concise facts on Ucilon Coatings in your latest "C.E.C." Or write for bulletin No. MC-6.

UNITED CHROMIUM, INCORPORATED
100 East 42nd Street, New York 17, N. Y.
Detroit 20, Mich. • Waterbury 20, Conn.
Chicago 4, Ill. • Los Angeles 13, Calif.
In Canada:
United Chromium Limited, Toronto, Ont.

trial chemicals used by the region's textile, paper, plywood, foundry, paint and plastic industries.

Union Carbide & Carbon Corp.—New quarters in Seattle to house offices and distributing facilities for Carbide & Carbon Chemicals Co., Linde Air Products Co., National Carbon Co. and Haynes Stellite Co., all divisions of the corporation.

Shell Chemical Corp.—A distribution center in Industry, Pa., to be operated by Great Lakes Solvents, Inc. It is located to service industries in Pittsburgh, western Pennsylvania and eastern Ohio.

Michigan Tool Co., Detroit—A separate division to manufacture and market a new line of chemical products. It will be known as the Shear-Speed Chemical Products Div.

Geigy Co., New York—An addition to its Leland, Miss., plant. The company makes pharmaceuticals, insecticides, agricultural chemicals and dyestuffs.

Parker Appliance Co., Cleveland, Ohio—District sales offices in Cleveland and Los Angeles.

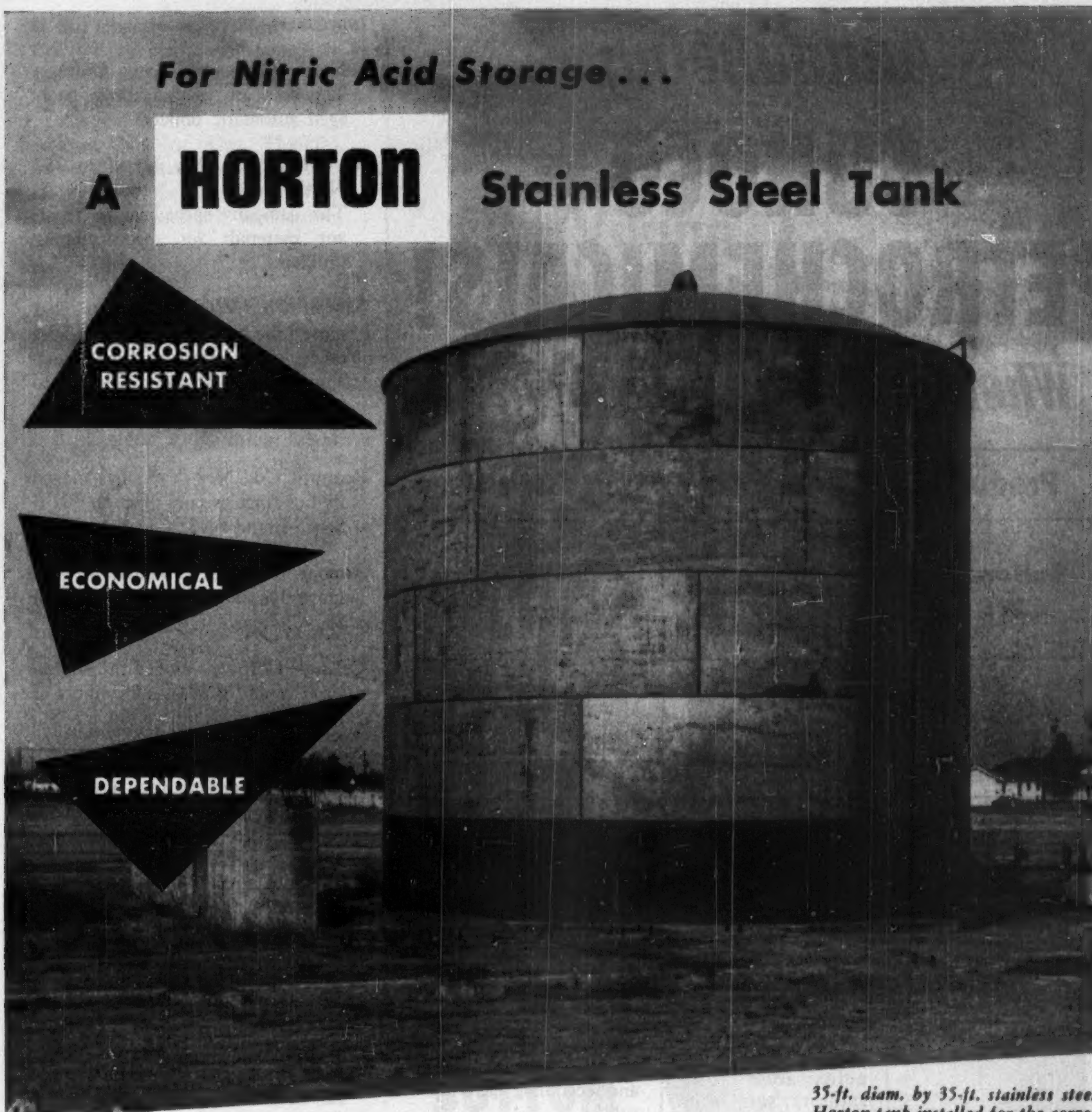
Monsanto Chemical Co.—A new building in Santa Clara, Calif., for the western division administrative headquarters, to be moved from Seattle. The new unit will be built next to the present Santa Clara plant, which produces butylated melamine and urea resins.

Scott Paper Co. of Chester, Pa.—A paper mill at Everett, Wash., to go into operation early next year. It is expected to cost almost $5 million.

NEW LOCATIONS

York Engineering & Construction Co. and York-Gillespie Mfg. Co. have relocated all of their fabricating shops, machine shops, general offices and engineering departments at one large plant at 39th St. and Allegheny Valley R.R., Pittsburgh, Pa.

Orr & Sembower, Inc., Reading, Pa., has moved its midwestern district office from Cleveland to 4809



35-ft. diam. by 35-ft. stainless steel Horton tank installed for the corrosion-resistant storage of nitric acid at a Louisiana petro-chemical plant.

Commercial Solvents Corporation uses a stainless steel tank to store 60 per cent nitric acid at its Sterlington, La., plant. The 35-ft. diam. by 35-ft. structure is made entirely of stainless steel except for a carbon steel angle around the top of the shell.

During the field erection of this structure a Chicago Bridge & Iron Company Welding Supervisor was assigned to the job to instruct welding personnel, check welding equipment and supervise the cutting and grading of test plugs. It was his job to see that all requirements set forth in the specifications were met. Field supervisory service of this type is standard practice on all Chicago Bridge & Iron Company structures.

Write our nearest office for quotations on tanks made of carbon steel or corrosion-resistant metals. There is no obligation on your part.

CHICAGO BRIDGE & IRON COMPANY

Atlanta 3....2120 Healey Bldg.
Birmingham 1....1510 North Fiftieth St.
Boston 10....1005-201 Devonshire St.
Chicago 4....2124 McCormick Bldg.
Cleveland 15....2220 Midland Bldg.
Detroit 26....1503 Lafayette Bldg.
Havana....402 Abreu Bldg.
Houston 2....2103 C & I Bldg.
Los Angeles 17..1505 General Petroleum Bldg.
New York 6....3318—165 Broadway Bldg.
Philadelphia 3...1625—1700 Walnut St. Bldg.
Pittsburgh 19....Alcoa Bldg.
San Francisco 4....1522—200 Bush St.
Seattle 1....1305 Henry Bldg.
Tulsa 3....1623 Hunt Bldg.

Plants in BIRMINGHAM, CHICAGO, SALT LAKE CITY and GREENVILLE, PENNSYLVANIA

North Claremont Ave., Chicago. The company manufactures packaged automatic boilers.

Ray Miller, Inc. has moved to 252 North Tenth St., Newark, N. J. The company specializes in resistant materials for special piping problems.

Norton Co., Worcester, Mass., has moved the New York domestic sales offices of its abrasive, grinding machine and refractories divisions to Green and North Sts., Teterboro, N. J.

Permutit Co., New York, has moved its Los Angeles sales office to 302-B South Brand Blvd., Glendale, Calif.

Armour Research Foundation will move this summer to 10 West 35th St., Chicago.

Celanese Corp. has moved the administrative and general sales offices of its plastics division to 290 Ferry St., Newark, N. J.

Raybestos-Manhattan, Inc., has moved its Chicago offices and warehouse to 6010 Northwest Highway.

Innis, Speiden & Co. has moved in with its sister organization, Berkshire Chemicals, Inc., at 420 Lexington Ave., New York.

NEW COMPANIES

John Powell S. A. Comercio e Industria, Porto Alegre, Brazil, to provide an additional manufacturing and distribution point for the parent company, John Powell and Co., New York manufacturer of basic materials for insecticide producers.

Chevron Oil Co., a wholly-owned subsidiary of Standard Oil of California, to carry on geophysical work. President will be J. W. Hoover, formerly vice president and director of the California Co., another subsidiary.

Allen Engineering Co., Cranford, N. J., to specialize in handling sales of chemical process equipment. The new company will handle in the New York area the porcelain, stoneware and plastic equipment of General Ceramics and Steatite Corp.

It will also represent Mission Mfg. Co. for its centrifugal pumps in north Jersey, metropolitan New York and New England.

Houghton Vix-Syn Co., Hopkins, Minn., to manufacture synthetic rubber packings used to seal hydraulic and pneumatic mechanisms of all types.

NEW NAMES

Industrial Equipment Co., Chicago, has changed its name to Industrial Crane & Hoist Corp.

W. B. Connor Engineering Corp., Danbury, Conn., manufacturer of ceiling air diffusers and activated carbon air purifiers has shortened its corporate name to Connor Engineering Corp.

Nuclear-Chicago will be the name used in the future advertising and sales promotion of Nuclear Instrument & Chemical Corp. because of the large number of firms having names similar to the corporate title.

Shield Coatings Corp., Verona, N. J., has changed its name to Shield Chemical Corp.

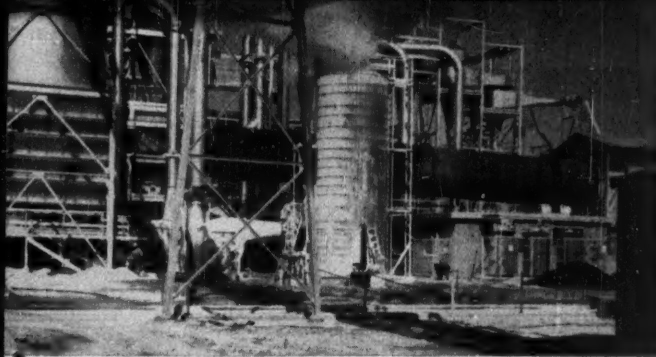
Kolker Chemical Works, Inc., a subsidiary of Diamond Alkali Co., Cleveland, has changed its name to Diamond Alkali Organic Chemicals Div., Inc.

NEW LINES

Steelcote Mfg. Co., St. Louis, Mo.—Coatings for steel which use a vinyl plastic vehicle and which contain a pigment which allows the manufacture of all colors. Called Steelast, the product is said to produce a tough film which is impervious to moisture, resistant to most chemicals and is odorless and nontoxic when dry.

Parker Appliance Co., Cleveland—Pumps and valves and special hydraulic units formerly made by the hydraulic division of Sunstrand Machine Tool Co., Rockford, Ill.

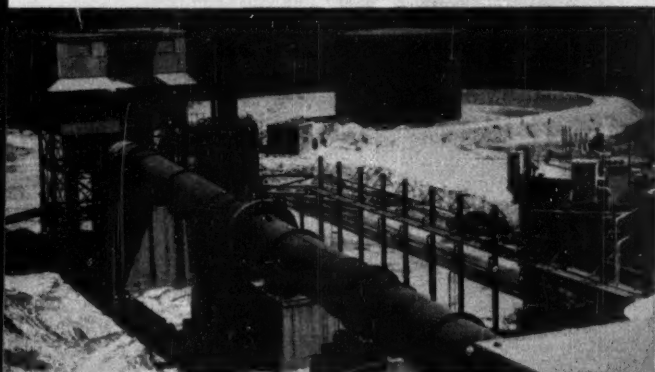
Synvar Corp., Wilmington, Dela.—High impact phenolic molding compounds to supplement its present general purpose line. —*End*



Lompoc, Calif. - An 11'0" x 100'0" Kiln producing Diatomaceous Earth.

Jamaica, B.W.I. - 9'0" x 175'0" Traylor Kiln used in the processing of Bauxite.

Acme, N.C. - Traylor 8'6" x 215'0" Lime Sludge Recovery Kiln in plant of well known paper manufacturer.



Chile, S.A. - 7'6" x 315'0" for calcining lime, used in the processing of copper ore.

ranging in size from 7' diameter up to 11' diameter x 400' long

Gardanne, France - 9'6" x 250'0" Rotary Kiln installed in the modern alumina plant of a well known overseas company.

Suriname, S.A. - Two of many Traylor Kilns installed in Latin America, these 8'0" x 120'0" kilns will be used in the production of Alumina.

A *Traylor* Leads to Greater Profits

York, Pa. - It took 7 flat cars to ship this 10' x 300', 3 section Traylor Kiln to this leading Dolomite producer.

Soon to be released! A new, fully illustrated, bulletin on Traylor Rotary Kilns is now in preparation. It will show the many superior features of Traylor Rotary Kiln design in detail. Mail the coupon today to be sure of getting up-to-date information you can't afford to miss.

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For any job which involves the handling of large volumes, heat and high pressures—either singly or all at one time—Allegheny Metal solid or clad plates are produced in the exact stainless grade required to combat corrosion, oxidation and contamination of the product.

Some of these grades are *new* . . . comparatively recent developments of our research and experience as a pioneer and leader in stainless steel production. Others are improved versions of older analyses. The latest information on the entire subject of stainless plates is available to you in the booklet illustrated above—32 pages of valuable data on types, sizes, finishes, fabricating methods and uses, including ASTM and ASME boiler codes.

Specify "Allegheny Metal" for complete reliability in stainless steel plates, and write for your copy of the A-L Plate Book. ● *Address Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pennsylvania.*

You can make it BETTER with

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AL TIME-TESTED STAINLESS STEEL

WBD 4877

Chemical Engineer's Bookshelf **Edited by Lester B. Pope**

In Retrospect

I REMEMBER. By Dexter S. Kimball. McGraw-Hill Book Co., New York. 259 pages. $4.

Reviewed by H. C. Parmelee

Part of the charm of Dean Kimball's autobiography lies in the modesty with which he relates his participation in events and affairs of great significance in the development of American industry and education. His active life spanned the most remarkable era in the history of engineering education, industrial organization, and management. And he was an integral part of it, not merely an intelligent bystander. So he wrote with first-hand knowledge and authority. But though he tells a fascinating story, those who knew him well will realize how difficult, if not impossible, it was for him to reveal his own strong personality which was, of course, a large factor in his successful career. His warm smile, cordial greeting, friendly handclasp, and sincere sociability with men of high and low degree, left indelible impressions on all with whom he worked and played.

Running through the autobiography is a thread of philosophy of timely importance for young engineers in particular. Here is sturdy independence that asks only for opportunity, not security; a record that reveals personal growth in a job until he is too big for it, but ready for the next; wisdom to realize when he is up against a stone wall, and courage to quit a job and prepare himself for more important work. He found that an able man was always in demand, and that a reputation made in one job was his best recommendation for the next.

Dean Kimball was at home anywhere in the United States. He knew the forests of Maine and Washington. He saw the pioneer luxury of Nob Hill in San Francisco, and he experienced the rugged life of Butte, Mont. In California he gained knowledge as a machine-shop apprentice and as a student at Stanford. After a short stay at Cornell University in a subordinate faculty position he went into industrial work at Pittsfield, Mass., but returned to Cornell where he ultimately became dean of the college of engineering. Thus in his career he combined machine shop practice with engineering instruction, greatly to his advantage as a teacher and administrator.

It was inevitable that one so broadly experienced should be called upon to serve his country in time of war, and his fellow engineers in their professional organizations. He was honored with four gold medals, and was the recipient of five honorary degrees, all indicative of an active and useful career. Engineers generally, and Cornell engineers in particular will find in the dean's autobiography a stimulating reminder of incidents and events in American industry and education.

Hydrides

AN INTRODUCTION TO THE CHEMISTRY OF THE HYDRIDES. By Dallas T. Hurd. John Wiley & Sons, New York. Price $5.50. 231 pages.

Reviewed by B. Elpern

Here is an aptly named book. As the author points out, it is not intended to be an all-inclusive compendium, but rather a critical and coordinated presentation of the theory, the properties and reactions of hydrides.

Recent wide applications of the hydrides of lithium, sodium, boron and silicon have stimulated a new interest in inorganic chemistry not only by those working in the field but by organic chemists and engineers as well. Dr. Hurd has attempted to present material of interest to a vast chemical audience. The scope of the presentation can be seen by examining the table of contents. The first three chapters define terms, and consider the chemical bonding and structure of the hydrides. The next thirteen chapters discuss the hydrides in groups defined by the so-called long-form periodic table. Herein are presented the hydrides of the alkali metals, alkaline earth metals, beryllium and magnesium, covalent, transitional and borderline elements, elements of groups III, IV, V, VI, VII, and bases, and complexes. There is a final chapter on nomenclature and an appendix containing information on the deuterides, toxicology, vacuum manipulation and contemporary commercial sources of the hydrides. There is an adequate author and subject index.

Since the hydrides of the halogens, oxygen, sulfur and carbon are treated in numerous other works, Dr. Hurd has conserved space by devoting minimal attention to these.

For each hydride, its physical and chemical properties, structure and preparation are given wherever known.

The publishers have done well by the author in presenting a valuable addition to the chemist's library.

Without Water

NON-AQUEOUS SOLVENTS. (Applications as Media for Chemical Reactions.) By Ludwig F. Audrieth and Jacob Kleinberg. John Wiley & Sons, New York. 284 pages. $6.75.

Reviewed by F. C. Nachod

The cosmological accident which makes water the "universal" solvent on our globe provides a parochial attitude in many of us. Indeed, in carrying out chemical reactions we are often overlooking the important aspect of selecting the best solvent for the system. Drs. Audrieth and Kleinberg have provided a very readable monograph in which they develop the subject matter with great care. Leading off with a brief historical survey they discuss acid-base concepts and then introduce the main subject: solvents. The coverage is very comprehensive, from ammonia and nitrogenous compounds to acetic and sulfuric acids, acid chlorides, hydrogen fluoride, sulfur dioxide and halogens. A chapter on high temperature systems (melts) concludes the work. Over 80 tables are found within the covers replete with information on solvent properties. The book can be recommended to those who are confronted with solvent problems but will be particularly valuable to workers who by force of habit or laziness did not give sufficient consideration to "non-aqueous" solvents.

Recent Books & Pamphlets

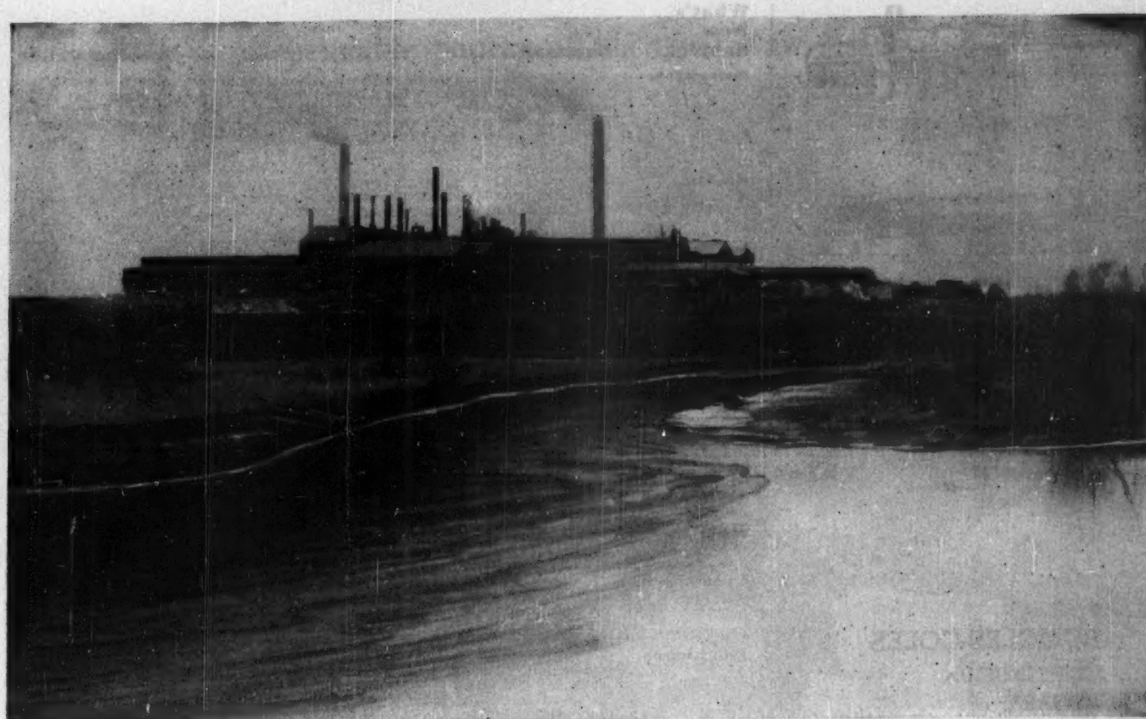
Subject	Summary	How to Order
Condensers	Newly revised standards for steam surface condensers contains sections on: nomenclature, definitions, condenser performance, materials and details of construction, surface condenser sizes, vacuum pump capacity, atmospheric relief valve sizes. 17 pages.	"Standards for Steam Surface Condensers." Heat Exchange Institute, 122 East 42nd St., New York 17, N. Y. $2.
Bearings	Specifications for metal powder sintered bearings (oil impregnated). Covers such factors as composition, basis of purchase, density, porosity, crushing strength requirements.	Standard 16-52T. Metal Powder Assn., 420 Lexington Ave., New York 17, N. Y. 25 cents.
Nuclear Reactors	Outline of a practical method of building a small reactor for experimental use. Describes nuclear reactors in some detail; indicates the approach to selecting research reactors; explains their methods, and offers, in concise analyses, some cost studies and contract procedures. Nine chapters by various experts in the nuclear energy field.	"A Handbook on Small Research Nuclear Reactors for Universities and Industry." By Ernest H. Wakefield. Radiation Counter Laboratories, Inc., Nucleonic Park, Skokie, Ill. $6.
Petroleum	Readily usable compilation of most of the latest ASTM standards, test methods and specifications widely used in the petroleum products and lubricants field. 831 pages.	"ASTM Standards on Petroleum Products and Lubricants." American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. $5.75.
Wooden Equipment	Compilation of 26 papers by leading engineers and wood technologists on the contributions of the chemical and wood preserving industries in extending the service life of wood as an engineering and industrial material. 112 pages.	"One Hundred Years of Engineering Progress With Wood." Timber Engineering Co., Dept. WS-P, 1319 18th St., N.W., Washington 6, D. C. Gratis.
Research	The formation and definition of research and development objectives, the evaluation of individual and group performance with reference to objectives. A series of papers and conference reports. 103 pages.	"Evaluating Research and Development." By Irving R. Weschler and Paula Brown. Institute of Industrial Relations, University of California, Los Angeles 24, Calif. $1.65.
Steel Piping	December 1952 edition of a compilation of 56 widely used specifications for carbon-steel and alloy-steel pipe and tubing, including stainless. 394 pages.	"ASTM Specifications for Steel Piping Materials." American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. $3.75.
Waste Treatment	The sources, volumes and concentrations of phenolic wastes and methods for reduction by process changes or treatment. The findings from a survey of 17 plants that produce 80 percent of the coke in the Ohio River Valley. 36 pages.	"Reducing Phenol Wastes From Coke Plants." Ohio River Valley Water Sanitation Commission, 414 Walnut St., Cincinnati 2, Ohio. $1.
Rubber	Discussion of the question whether disposal of the government-owned facilities at this time would be consistent with national security and thereafter to the methods of disposal which are deemed appropriate to assure the development within the United States of a free competitive rubber industry. 61 pages.	"Program for Disposal to Private Industry of Government-Owned Rubber-Producing Facilities." Reconstruction Finance Corp., Washington 25, D. C.

—End

CE's Guide to

NEW TECHNICAL LITERATURE

What's New In . . .	How to . . .	Company . . .
Plastics (A)	. . . find new solutions to engineering pro[illegible]ems through the use of Teflon in gaskets, va[illegible]e packings, expansion joints. Also discusses [illegible]e advantages of the company's Rulon bearing material. 4 p.	Dixon Saddle Co., P. O. Drawer 7, Bristol, R. I.
Pumps (B)	. . . provide heavy machinery [illegible]th precise control of torque, acceleration [illegible]eleration, speed or reversal by using a [illegible] of large capacity oil hydraulic pumps [illegible]ors. Performance data and drawings.	Waterbury Tool Div., Commercial Hydraulic Dept., Waterbury 91, Conn.
Pelargonic Acid (C)	. . . reduce costs in filling your [illegible] a medium molecular weight, saturated, [illegible] acid. Tentative specifications, typical [illegible]ristics, reactions and applications of a [illegible]roved grade of pelargonic acid. 3 p.	Emery Industries, Inc., Dept. 5, Carew Tower, Cincinnati 2, Ohio
Pressure Transmitter (D)	. . . get dependable pneumatic [illegible]sion, adjustable 3 to 15 psi. output [illegible]th this company's new model 173. 4 p.	Moore Products Co., Philadelphia 24, Pa.
Motors (E)	. . . select motive power to handle [illegible]ustrial applications. Text and illustra[illegible] integral horsepower motors and gen[illegible] 50 p.	Allis-Chalmers Mfg. Co., 1147 South 70th St., Milwaukee, Wis.
Pumps (F)	. . . maintain high efficiency for [illegible]d periods with the company's rubber [illegible]nd pumps. Case histories show how rub[illegible]s compare with hard iron or steel parts. [illegible]l views, clearance and foundation dimen[illegible]stallation and maintenance data. 20 p.	Denver Equipment Co., 1400 17th St., Denver, Colo.
Spray Dryers (G)	. . . use a spray dryer most effec[illegible]n various types of applications. Why [illegible]ry; what is spray dried; how a spray [illegible]orks (each step is discussed separately). [illegible]aphs show some recent commercial spray [illegible]stallations made by this company. 12 p.	Bowen Engineering, Inc., North Branch, N. J.
Materials Handling (H)	. . . load and unload cars and ships [illegible]g a choice of this company's line of [illegible]oaders and other equipment. Photo[illegible] and diagrams show operation and instal[illegible]4 p.	Stephens-Adamson Mfg. Co., Aurora, Ill.
Valves (I)	. . . select from a complete line of [illegible]on and bronze valves, lubricating devices, [illegible]mountings, cocks and other products. De[illegible]descriptions and illustrations. Includes [illegible]age thumb-index guide to valve selec[illegible]06 p.	Lunkenheimer Co., Cincinnati, Ohio.
Analysis (J)	. . . take advantage of this firm's [illegible]s for chemical, physical and metallurgical [illegible] of alloys, minerals, ores and scrap. 4 p. [illegible]r bulletin describes the firm's facilities [illegible]alysis, testing, research and development [illegible]s and beverages. 4 p.	Research and Development Laboratories, 1138 East North Ave., Baltimore 2, Md.
Instruments (K)	. . . automatically control your [illegible]es via light measurement with a super[illegible]ve colorimetric instrument. 4 p.	Instrument Development Laboratories, 163 Highland Ave., Needham Heights 94, Mass.
Instruments (L)	. . . detect and measure micro [illegible]ties of gaseous material in streams or [illegible]pheres with a color comparator. Opera[illegible]pplications. Schematic diagram. 4 p.	Vitro Corp. of America, 233 Broadway, New York 7, N. Y.
Instruments (M)	. . . replace the human observer [illegible]cise color matching problems with a new [illegible]rial color measuring and comparison in[illegible]ent. 4 p.	Instrument Development Laboratories, 163 Highland Ave., Needham Heights 94, Mas.
Work Clothes (N)	. . . save up to 80 percent of work [illegible]s cost with this company's orlon garments. [illegible]stics on chemical resistance; comparisons [illegible]other fabrics. 16 p.	Workion Inc., Dept. U-D, 253 West 28th St., New York 1, N. Y.
Plastic (O)	. . . take advantage of the physi[illegible]lectrical and chemical properties of Du [illegible]s new Mylar polyester film. Charts, dia[illegible]s and tables aid discussion of properties [illegible]pplication suggestions. 14 p.	E. I. du Pont de Nemours & Co., Film Dept., Sales Development and Technical Services Section, Wilmington 98, Del.
Valves (P)	. . . find the valve, manual or automatic, which you need for rugged, dependable service. Fully illustrated catalog and engineering sections cover this company's comprehensive line. 48 p.	Gas Machinery Co., 16100 Waterloo Rd., Cleveland 10, Ohio.
Instruments (Q)	. . . automatically feed treat chemicals either to maintain uniform concentrations or to correct variations of pH in any continuous process. Bulletin describes feeder control in relation to flow rate, changing the feed rate by ratio-set mechanism, range of ratio adjustment and control of pH under conditions of wide and narrow flow variations. 4 p.	Foxboro Co., Foxboro, Mass.



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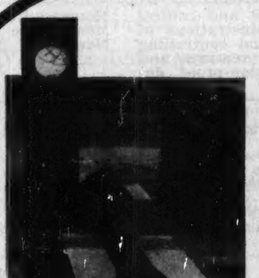

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PRESSURE · LEVEL
GAS ANALYSIS · RATIO

What's New Subject	Summary	How to Order
Instruments (A)	. . . handle difficult laboratory and production line tasks with x-ray diffraction and x-ray spectometry. Diagram clearly shows the arrangement and geometry that underlies the basic design of the two types of instruments. 4 p.	North American Philips Co., 750 South Fulton Ave., Mount Vernon, N. Y.
Roofing (B)	. . . simplify re-roofing by using a new cold-process method which needs no special equipment and eliminates fire hazard in application. 4 p.	Tropical Paint & Oil Co., Cleveland 2, Ohio.
Carbon Black (C)	. . . evaluate the properties of colloidal carbon for various uses. 30 p.	Binney & Smith Co., 41 East 42nd St., New York 17, N. Y.
Packaging (D)	. . . properly apply polyethylene bags and liners. Sketches show applications. 4 p.	Plastic Packaging Co., 730 North Franklin St., Chicago 10, Ill.
Polyethylene (E)	. . . fabricate and make the best use of polyethylene. Describes pipe for water service, wiring conduit, mine and chemical piping. 24 p.	Bakelite Co., 260 Madison Ave., New York 16, N. Y.
Steel (F)	. . . identify carbon steel specifications in seconds. Chart shows chemical analysis requirements for each of 60 military, aeronautical and federal specifications. Also listed are specified forms and nearest corresponding SAE, AISI and AMS type numbers. Regular file-card size.	Peter A. Frasse and Co., 17 Grand St., New York 13, N. Y.
Fungicides (G)	. . . preserve paints from mildew and mold with sodium pentachlorophenate, pentachlorophenol and copper 8-quinolinolate. 4 p.	Monsanto Chemical Co., St. Louis 4, Mo.
Maintenance (H)	. . . clean and maintain clad steel equipment. Procedures, recommended solution formulas for cleaning specific kinds of surfaces, data on handling clad steel equipment during relocations. 10 p.	Lukens Steel Co., Coatesville, Pa.
Atoms (I)	. . . become familiar with the different kinds of atoms now known to exist (nearly 1,300). Wall chart and booklet. Fourth edition up to date as of November 1952.	General Electric Co., Schenectady 5, N. Y.
Pumps (J)	. . . benefit from this company's Hypro 4000 Series Roller Pump. Outlines new construction details. Illustrations show several sections of the pump and components. Performance tables, technical drawings giving overall dimensions and sizes.	Hypro Engineering, Inc., 404 North Washington Ave., Minneapolis, Minn.
Materials Handling (K)	. . . solve materials handling problems by choosing from this company's line of equipment. Over 50 drawings classified into such categories as package handling, bulk handling, roller and wheel conveyor. 4 p.	Kornylak Engineering Corp., 513-521 Communipaw Ave., Jersey City 4, N. J.
Insulation (L)	. . . find the exact degree of protection from condensation which is afforded by this spray applied cork and Gilsonite mastic insulation. Charts.	Insul-Mastic Corp. of America, 1141 Oliver Bldg., Pittsburgh 22, Pa.
Lubricants (M)	. . . simplify and save with pure industrial lubricants. Six simple steps to streamline your lubrication program.	Pure Oil Co., 35 East Wacker Dr., Chicago 1, Ill.
Packaging (N)	. . . pack it. Illustrates and describes 12 different styles and types of standard corrugated boxes as well as 72 corrugated specialty boxes. Recommendations as to the type of products for which each box is best suited. 30 p.	Hinde & Dauch Paper Co., Sandusky, Ohio.
Maintenance (O)	. . . sweep cleaner with a device composed of dual brushes arranged in tandem and operating in opposite directions. 4 p.	Moto-Mower Co., 4600 Woodward Ave., Detroit, Mich.
Instruments (P)	. . . get continuous accurate indication and recording of dewpoint temperature in a gas stream with this company's indicator and recorder. Photographs and diagrams of units. Applications, operation principles. 8 p.	General Electric Co., Schenectady, N. Y.
Instruments (Q)	. . . record or record and control viscosity in industrial plants. Illustrations of models of indicating, recording and controlling equipment for various operating pressures and for applications requiring explosion-proof design. 8 p.	Norcross Corp., 247 Newtonville Ave., Newton 58, Mass.
Rubber (R)	. . . repair conveyor belts with a plastic rubber compound. Case histories.	Magic Chemical Co., 121 Crescent St., Brockton 2, Mass.
Autoclaves (S)	. . . obtain autoclaves for pressure-temperature reactions such as hydrogenation, ammonolysis, polymerization and organic synthesis. Materials of construction, types of agitation, stuffing boxes, instrumentation and safety features of the line. 48 p.	Blaw-Knox Co., Process Equipment Dept., Farmers Bank Bldg., Pittsburgh 22, Pa.
Organic Chemicals (T)	. . . fill your needs for solvents, industrial chemicals, resins and plastics as well as anhydrous ammonia fertilizers and agricultural chemicals. Properties, specifications and applications. 92 p.	Shell Chemical Corp., 50 West 50th St., New York 20, N. Y.

What's New In . . .	How to . . .	Company . . .
Instruments (A)	. . . get continuous treating-sampling-blending-diluting in process operations with a method of combining fluid meters and proportioning. Numerous diagrams show operation, construction and dimensions, installation. 28 p. Another bulletin contains photographs of a line of chemical feeding and proportioning pumps. Capacity schedule, list of chemicals handled. 16 p. A third lists bulletins and reprints which the company has available on its products. 6 p.	%Proportioneers, Inc. %, P. O. Box 1442, Providence 1, R. I.
Process Equipment (B)	. . . automatically form steam to meet peak process demand with a steam accumulator. Principles and practical application. How to calculate required capacity for your needs. 8 p.	Foster Wheeler Corp., 165 Broadway, New York 6, N. Y.
Pumps (C)	. . . supply, circulate and boost water and clear liquids at medium and high heads by choosing from a line of 2,3,4 and 5-stage split-case pumps. 12 p.	Peerless Pump Div., 301 West Ave. 26, Los Angeles 31, Calif.
Valves (D)	. . . locate the right solenoid valve for your application. Photographs, specifications, diagrams and photographs of a line including general purpose and explosion-proof models, those with small ports for high-pressure service and larger ports for increased flow capacity, super-duty four way solenoid valves with poppet-type seats. 80 p.	Automatic Switch Co., 391 Lakeside Ave., Orange, N. J.
Air Conditioning (E)	. . . purify air so effectively that even tobacco smoke is removed with a filter made of silene-treated, moisture-resistant fiber of asbestos and grass. Construction and operation diagrams. 4 p.	Mine Safety Appliances Co., Braddock, Thomas and Meade Sts., Pittsburgh 8, Pa.
Instruments (F)	. . . get accurate, high speed process monitoring and control with this company's 21-610 mass spectrometer. 4 p.	Consolidated Engineering Corp., 300 North Sierra Madre Villa, Pasadena 15, Calif.
Instruments (G)	. . . take advantage of the analytical service and products of a company that produces such instruments as mass spectrometers, leak detectors, micromanometers. How the various products aid different types of applications. 8 p.	Consolidated Engineering Corp., 300 North Sierra Madre Villa, Pasadena 15, Calif.
Dust Collector (H)	. . . reduce operating and maintenance costs with a self-cleaning collector. How it works (with diagrams), sizes, construction specifications. 6 p.	Pangborn Corp., Hagerstown, Md.
Instruments (I)	. . . keep advised of this company's testing equipment and other products used for jet aircraft and engines, rocket motors and guided missiles. Vol. 1, No. 1 of a house organ.	Greer Hydraulics, Inc., 454 18th St., Brooklyn 15, New York
Heat Exchangers (J)	. . . solve a wide variety of industrial cooling and condensing problems with air-cooled heat exchangers. 12 p.	Fluor Corp., Ltd., 2500 South Atlantic Blvd., Los Angeles 23, Calif.
Diatomite (K)	. . . use diatomite for filter powder for water purification, dry cleaning and the production of foods and beverages, a mineral filler in the manufacture of paint, plastics, paper, fertilizers and insecticides. 28 p.	Johns-Manville, 22 East 40th St., New York 16, N. Y.
Instruments (L)	. . . use radioactivity in the petroleum industry. Brief descriptions, literature references. 16 p.	Tracerlab Inc., 130 High St., Boston 10, Mass.
Pumps (M)	. . . supply your plant with single-stage, double-suction centrifugal pumps (this company's Type S) for general water supply, circulating, gathering, drainage. 24 p.	Allis-Chalmers Mfg. Co., 1147 South 70th St., Milwaukee, Wis.
Instruments (N)	. . . fill your needs for pneumatic receivers which are furnished as indicating controllers, recorders and controllers. Construction and engineering details. 4 p.	Minneapolis-Honeywell Regulator Co., Wayne and Windrim Aves., Philadelphia 44, Pa.
Pumps (O)	. . . find suitable cradle-mounted, vertically split casing pumps for the wide range of medium duty services found in modern refinery and process pumping applications.	Ingersoll-Rand, 11 Broadway, New York 4, N. Y.
Conveyors (P)	. . . simplify loading and stacking jobs with a medium duty power belt conveyor. Specifications and features in clear, easy-to-read chart and table form. Sketches and photos show recommended installation procedures. 4 p.	Rapids-Standard Co., 342 Rapistan Bldg., Grand Rapids 2, Mich.
Nickel (Q)	. . . achieve the best results in plating nickel. Provides the designer, specifying engineer and user with basic information on electroplating and detailed information on electroplating and detailed information on nickel plating and its practices. This is a reoffer on a booklet first released last year. 44 p.	International Nickel Co., 67 Wall St., New York 5, N. Y.
Pumps (R)	. . . save space and money with this company's new small, DC-20 automatic pumping unit. Large diagram shows outside assembly. 4 p.	Farval Corp., 3249 East 80th St., Cleveland 4, Ohio.

What's New In . . .	How To	Company . . .
Fertilizers (A)	. . . use this company's Udet F detergents in the manufacture and conditioning of ammoniated mixed-goods. A summary of techniques. 4 p.	Universal Detergents, Inc., 1325 East Spring St., Long. Beach 6, Calif.
Chemicals (B)	. . . get more uniform pickling and better pickled surfaces through the use of pickling acid inhibitors. 4 p.	American Chemical Paint Co., Ambler, Pa.
Couplings (C)	. . . select the right flexible couplings. Specifications and dimensions charts, photographs of a comprehensive line. 50 p.	Lovejoy Flexible Coupling Co., 4949 West Lake St., Chicago 44, Ill.
Uranium (D)	. . . get a picture of the fast-growing uranium industry of the Colorado Plateau. Where uranium ores are mined and processed. Numerous photographs. 32 p.	United States Vanadium Co., Rm. 308, 30 East 42nd St., New York 17, N. Y.
Process Equipment (E)	. . . restore leaking condenser tubes by sealing off the deteriorated portion with inserts. 4 p.	Thomas C. Wilson, Inc., 21-11 44th Ave., Long Island City 1, N. Y.
Speed Drive (F)	. . . convert any standard constant speed motor to an infinitely variable speed drive with speed ratio up to 8:1. Photographs show flexibility in mounting. Rating tables, shaft center distances, complete dimensions. 4 p.	Reeves Pulley Co., Columbus, Ind.
Safety (G)	. . . find the tools to build plant safety programs and the training aids available for constructing supervisors and workers. Describes the facilities offered by the National Safety Council. 52 p.	National Safety Council, 425 North Michigan Ave., Chicago 11, Ill.
Heaters (H)	. . . use standard and heavy-duty centrifugal fan industrial heaters for large areas where conventional heating equipment is inadequate. Where to use them, at what circulating capacities and temperatures, how to place them. 32 p.	Westinghouse Sturtevant Div., Dept. T-025, 200 Readville St., Hyde Park, Boston 36, Mass.
Louvers (I)	. . . supply your plant with wall louvers designed to provide weatherproof inlets of sufficient size to supply the ventilating requirements along with rugged construction and with due regard to architectural relationship. 8 p.	Burt Mfg. Co., 44 East South St., Akron 11, Ohio.
Gas Burners (J)	. . . fill your spot heat treating needs with spear flame gas burners. Full size illustrations of the burners and flame length. Btu. capacity, port area and full dimensions. 4 p.	Selas Corp. of America, Philadelphia 34, Pa.
Process Equipment (K)	. . . keep up with developments at this company which makes such products as a Turba-Film evaporator, water turbines. Vol. 1, No. 1 of a house organ.	Rodney Hunt Machine Co., Orange, Mass.
Chlorosulfonic Acid (L)	. . . make the best use of it as a sulfonating or chlorosulfonating agent or as a catalyst in the production of dye intermediates, synthetic detergents, emulsifiers, DDT and alkylated benzenes. 12 p.	Monsanto Chemical Co., Organic Chemicals Div., St. Louis 1, Mo.
Engines (M)	. . . obtain gas, diesel and gas-diesel engines. Specifications, rating curve, space plans for this company's Type LS stationary engines. 12 p.	Cooper-Bessemer Corp., Mount Vernon, Ohio.
Steel (N)	. . . select and use cold finished carbon steel bars. Major characteristics and relative cost of a number of different analyses. Table of average mechanical properties and machining speeds. 8 p.	Joseph T. Ryerson & Son, Box 8000-A, Chicago 80, Ill.
Instruments (O)	. . . maintain constant liquid levels with this company's single-thyratron electronic instrument. Illustrations of the single-unit control, the probe and alternative schematic arrangements for installation. 4 p.	Thermo Instruments Co., 1166 El Camino Real, Belmont, Calif.
Gum Arabic (P)	. . . select the most efficient grade to fit a particular water soluble gum use requirement. Suggested uses in food, beverages, drugs, chemical specialties, coatings and sizings. 4 p.	Morningstar, Nicol, Inc., 630 West 51st St., New York 19, N. Y.
Gelling Agents (Q)	. . . judge the relative effectiveness of the various metallic soaps as gelling agents. Full descriptions of the procedures followed as well as the data obtained are given in the text and in the form of graphs.	Witco Chemical Co., 260 Madison Ave., New York 16, N. Y.
Hydraulic Cylinders (R)	. . . determine the size and to install the cylinder required for a particular application. Pictures, cutaway drawings and specifications of a wide variety of styles and sizes. 32 p.	Vickers Inc., 1400 Oakman Blvd., Detroit 32, Mich.
Standardized Buildings (S)	. . . expand your present plant or storage facilities by using standardized steel-frame structures. 20 p.	Luria Engineering Co., 500 Fifth Ave., New York, N. Y.
Instruments (T)	. . . take your pick of electronic AC line regulators. Describes a line with models of capacities ranging from 150 VA to 15 KVA. Includes information on electronic regulator circuitry, uses of regulators and requirements for special regulators. 16 p.	Sorenson & Co., 375 Fairfield Ave., Stamford, Conn.

—End

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High Surface Sodium

ON INERT SOLIDS

Just how reactive do you want your Sodium to be? If you want it at its maximum energy level, in an easily-handled, easily-controlled form, your answer is High Surface Sodium (HSS) on Inert Solids!

Using simple, easy-to-follow techniques, our researchers have applied atomic layers of Metallic Sodium to inert solids such as salt, soda ash, carbon, alumina and sand. HSS is free-flowing over a wide temperature range and has a large surface-to-weight ratio of Sodium. Reactions can be carried out in seconds instead of hours. The high surface area of Sodium in HSS, available for immediate reaction, is the key to its importance to industry.

HSS provides, through the complete and rapid reaction of Sodium, the following advantages:

¶ Easy control of reaction rates and temperatures above and below the melting point of Sodium

¶ Simple adaptation to continuous operations

¶ Dry-way reactions of Sodium

¶ Greater safety by eliminating flammable solvents

¶ High yields

¶ Preparation of products in finely divided and reactive states

¶ Means of avoiding induction periods

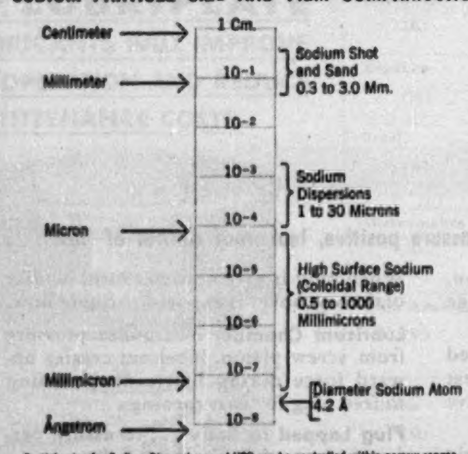
USES FOR HSS

1. Purification of gases, hydrocarbons and ethers (to remove oxygen, nitrogen, halogen and sulfur compounds, moisture and certain trace amounts of other impurities).
2. Preparation of Sodium Hydride and Sodamide for in situ use.
3. Reduction of Metal Salts and Oxides to finely divided metals, e.g., Zn, Fe, Pb, Cu, Ti, Ni, Pt, etc.
4. Catalyst for hydrocarbon cracking, polymerizations and rearrangement reactions.

APPARENT FILM THICKNESS VS. % Na IN HSS

% Na	Film Thickness on Alumina (Area—160 $M^2/g.$)	Film Thickness on Colloidal Carbon (Area—750 $M^2/g.$)
5%	1 Atomic Layer	<1 Atomic Layer
15%	Av. 2.5 Atoms Thick	<1 Atomic Layer
25%	Av. 5 Atoms Thick	Av. 1 Atom Thick

SODIUM PARTICLE SIZE AND FILM COMPARISONS



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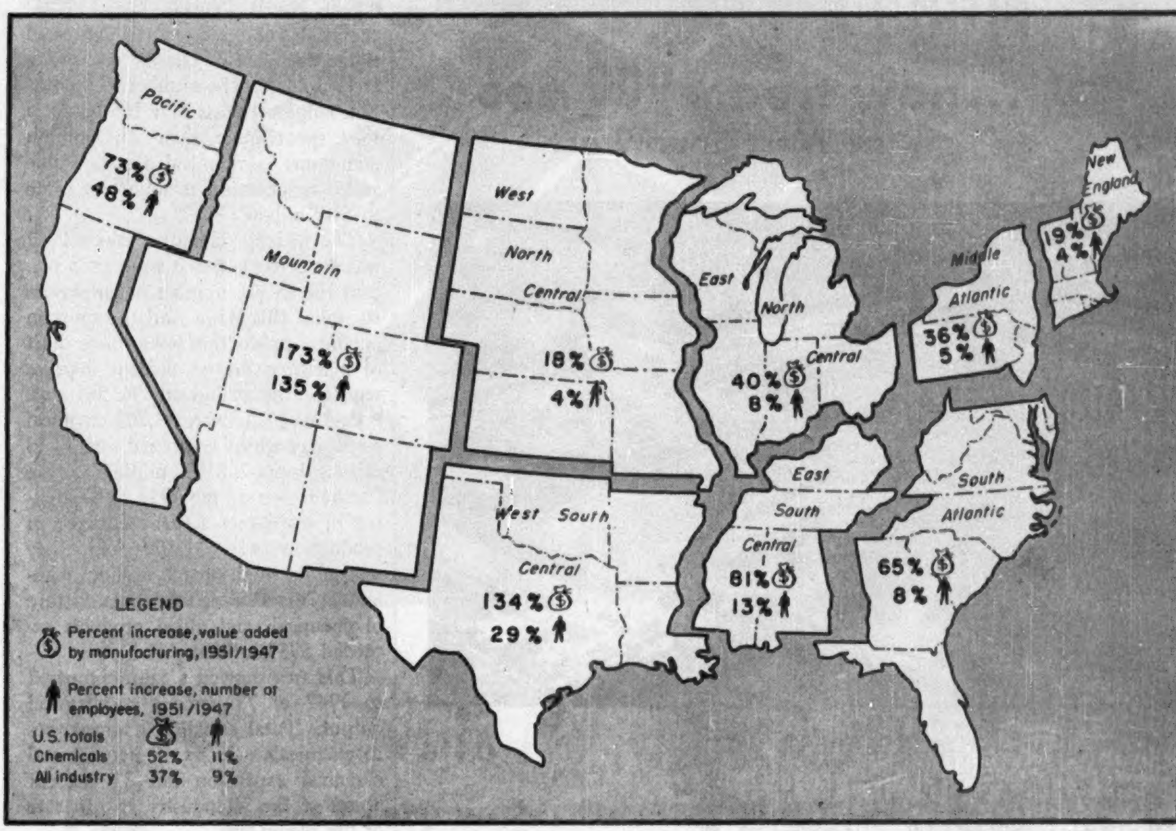


The Shifting Chemical Scene

Chemical and allied products output is still climbing much faster than U. S. manufacturing as a whole. Here's a detailed regional analysis of what's happened since 1947.

How did the chemical map of the U. S. change over the period 1947-1951? Did the combination of a business slide (1949) and the Korean war (1950) introduce dramatic changes into the regional pattern of the chemical industry?

Official statistics just released by the Bureau of Census offer the first detailed and reliable picture of the growth of the chemical industry on a regional basis. On many occasions the national story has been told in terms of capital expenditures, in terms of productivity, in terms of sales. Now, for the first time, the regional tale can be told.

The Bureau of Census has compiled statistics on chemical growth—for the period 1947-1951—for the nine regions shown on the map. By way of a yardstick: The number of employees in the nation's chemical plants rose 11 percent from 1947 to 1951. At the same time, the value added by the manufacture of chemicals (total value of products shipped less the cost of raw materials) rose 52 percent.

▶ **New England**—There were 29,600 employees in the New England chemical industry in 1951. Wages and salaries during that year topped $115 million. The 20,000 production workers in the industry worked a total of 41.8 million man-hours. Value added by manufacture in the region's chemical plants exceeded $258.5 million.

The figure for value added represents an increase of 19 percent over the 1947 level. Over the years 1947-1951 the total number of employees working in chemicals rose by 4 percent. The 19 percent rise in output, however, was not enough to keep pace with the 24 percent growth registered by all industry in New England.

▶ **Middle Atlantic**—In 1951 chemical employees in this area totaled 204,500. The industry payroll exceeded $841 million in the same year. Almost 140,000 of the industry employees were production workers and their combined labor came to 289 million man-hours. The value added by manufacture was $2.26 billion—by far the biggest regional figure.

The area boosted chemical output more than 36 percent since 1947. This gain was achieved with an increase of but 5 percent in the number of employees. The rate of chemical

growth surpassed by a third the 28 percent rise in the region's total industrial output.

▶ **East North Central**–The 155,200 chemical workers employed here had total wages and salaries exceeding \$641 million. The number of production employees was over 105,000 and they spent more than 218 million man-hours in chemical plants. Value added by chemical manufacture came to \$1.9 billion.

The increase in output since 1947 was 40 percent, but it took an 8 percent rise in the number of employees to realize this gain. And the spurt in chemical production fell a shade short of matching the 43 percent increase registered by all industry in this area.

▶ **Pacific**–There were 45,200 chemical employees whose combined wages and salaries topped \$195 million in the Pacific region during 1951. The number of employees actually engaged in production was 31,200 and they worked a total of 62 million man-hours. Value added by manufacture of chemicals and allied products exceeded \$533 million.

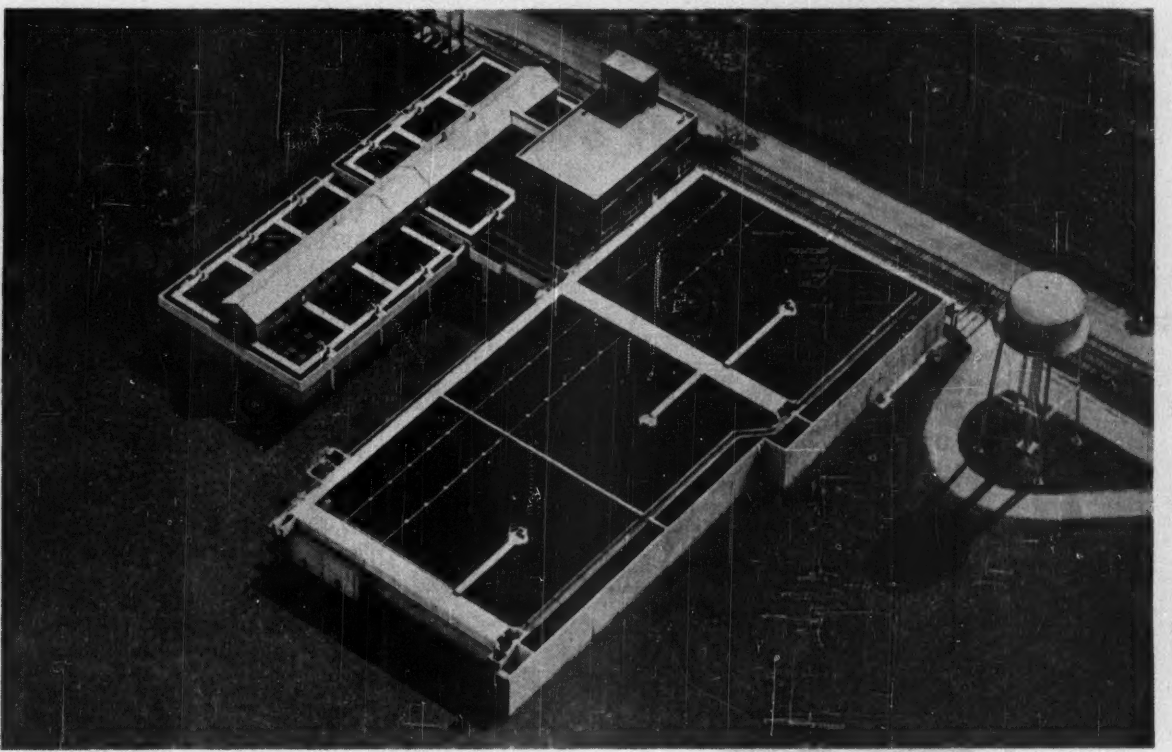
This area showed a gain–compared to 1947–of 73 percent in chemical output. Total number of employees in chemicals rose by 48 percent and chemical expansion ran 21 percent ahead of the all-industry growth rate of the region.

▶ **Mountain**–In 1951 there were 11,200 chemical employees in the area, an increase of 135 percent over 1947. Total payroll was \$47.7 million. The total number of production workers was 8,400 and their total work came to 18 million man-hours. The value added by manufacture was only \$109 million–the smallest regional total in the country.

The gain in output since 1947, though, was a staggering 173 percent. This phenomenal growth in chemicals far surpassed the 50 percent increase registered by all industry here.

▶ **West South Central**–Wages and salaries paid to the 54,400 chemical employees in this region in 1951 totaled almost \$212 million. The 40,800 production workers put in 87 million man-hours of work and the value added was \$909 million.

Production rose 134 percent since 1947; the number of employees went up by 29 percent. Chemical growth ran far ahead of the 59 percent jump chalked up by all industry in the area.



There's No "Magic Formula"

Every water treatment problem is different

No two water treatment problems are exactly alike. To get the best — and most economical — answer to your specific problem requires careful analysis of raw water composition, rate of flow and the results you require.

There *is* no magic formula . . . no single equipment unit that will give ideal results under all conditions. That's why it will pay you to check both conventional and high-rate units on every water treatment problem.

For a brief picture of the complete Dorr equipment line ask for Bulletin #9141. The Dorr Company, Stamford, Conn.

Repeat order in 1950 "proves out" a "conventional" installation made in 1948.

Quick facts about the Dorrco installation at the Hollingsworth & Whitney Co., Chickasaw Mills, Mobile, Alabama

1948 . . . First order installed with a design capacity of 10 MGD.
- 2 Dorrco Flash Mixers
- 1 Dorrco Flocculator
- 1 Dorrco Squarex Clarifier, 85' square

Operating Results . . .

Raw water:	Color — 65-70 ppm
Raw water:	Turbidity — 3.5-3.9 ppm
Finished water:	Color — 3 ppm

(Dosage in ppm: Alum 20, Soda Ash 15, Chlorine 3 to 5)

1950 . . . Second order installed with design capacity of 16 MGD. (Total design capacity: 26 MGD)
- 1 Dorrco Flash Mixer
- 2 Dorrco Flocculators
- 2 Dorrco Squarex Clarifiers, 75' square

Flocculator and Squarex are trademarks of THE DORR COMPANY—Reg. U. S. Pat. Off.

Every day, nearly 8 billion gallons of water are treated by DORR equipment.

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See Page 158

ECONOMICS, *cont. . .*

▶ **East South Central**—Chemical workers employed here in 1951 totaled more than 51,700 and the total payroll fell barely short of \$183 million. The 39,600 production workers spent 80 million man-hours on the job. Value added by manufacture came to \$527.6 million.

Chemical output climbed 81 percent since 1947. The number of employees rose by 13 percent. Chemicals gained more than twice as fast as all industry in the region.

▶ **South Atlantic**—Nearly 117,000 people worked in the chemical industry in 1951 and their combined wages and salaries exceeded \$417 million. Almost 89,000 of these employees were engaged in production and the total of their labor added up to 183 million man-hours. The value added by manufacture reached almost \$1.3 billion.

Chemical industry output rose 65 percent while the number of employees increased by 8 percent. This rise in production about doubled the percentage increase attained by all industry in this section.

▶ **West North Central**—More than 34,000 people worked in chemicals in 1951 and their total earnings were more than \$130 million. The 23,600 production workers spent 49 million man-hours in chemical factories. The value added by chemical manufacture was \$387.7 million.

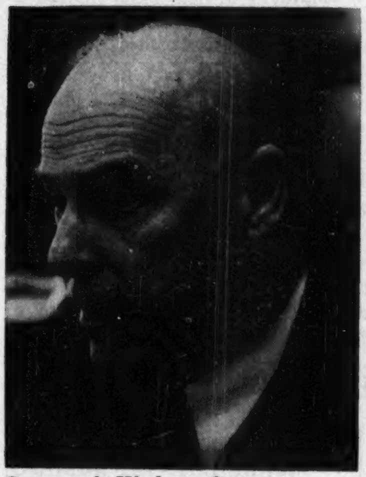
The 18 percent output gain registered by chemicals since 1947 was the most modest of all the regional increases and fell far short of the 38 percent rise of all industry in these states. The increase in the number of employees was 4 percent, compared to 14 percent for all industry.

▶ **Add It All Up**—In only three regions did chemical expansion lag behind the growth of industry generally.

The greatest percentage gain in output over the years 1947-1951 was registered by the Mountain region—the least important area in terms of dollar volume of chemical production. The Middle Atlantic and the South Atlantic areas showed the greatest output gains per new employee added. Both regions stepped up production more than 7½ percent for every 1 percent increase in the number of employees. For the rest of the nation, an increase of 1 percent in the num-

ber of chemical employees brought barely a 4 percent increase in output.

These brand new facts and figures tell a story of a bigger, more productive and constantly shifting chemical industry throughout the country.



Commerce's Weeks predicts . . .

Fair and Warmer

"Its [the new Administration's] arrival in Washington on January 20 changed the economic climate overnight. The political weather for business is fair and warmer . . . I predict even brighter days ahead."

This recent statement by Secretary of Commerce Sinclair Weeks before the Pittsburgh Chamber of Commerce sets the tone of the Commerce Dept.'s new attitude toward its job. After 20 years of competing with business—big and little—government is now striving to serve all the people equally without any doubletalk.

"We are not excluding any area of society from our concern. This means that the 'forgotten man' of recent years, the businessman, now gets his rights, too. The handcuffs are removed from his wrists and the gag from his mouth."

And Weeks has a positive program. One of Commerce's chief jobs is to be the "ear for business, the voice of business and the friend of business." Let's examine that job.

▶ **Ear for Business**—Until recently, many businessmen have gotten the brush-off in Washington. Miles of red tape and uninterested bureaucrats have made it almost impossible for business to get a fair shake.

Not so now! By acting as "the listening post to which businessmen can bring their opinions and their questions," Commerce intends to

eliminate all browbeatings and brush-offs.

"But," says Weeks, "because businessmen can expect an attentive ear, it seems to me—a former businessman—that responsible business should ponder seriously upon what it proposes to say. Before saying anything it should realize that the chief business of businessmen today—and all other Americans—is to help make sure of national security.

"The acid test of one's sincerity about thrift in government is to act on the principle that economy—like charity—begins at home."

▶ **Voice of Business**—Not only will businessmen be listened to, but their ideas will be passed along. Thus, the President and the Cabinet will be able to weigh the various opinions of business in determining major policies.

". . . your arguments always will be heard and repeated up and down the line, even though Commerce may not be able to agree with all of them."

▶ **Friend of Business**—"Finally, our concept is a Commerce Department which is the active friend and advocate of business, using the special facilities of national government to foster, promote and develop commerce and industry."

This performance of necessary services beyond the means of private industry—census facts, Bureau of Standards research files, business surveys—will give management valuable data for planning and acting.

"As I view the entire economy I find that current business is good. Expectations of sales reveal continued optimism. The new administration is trying to conduct government in a manner that will encourage private enterprise and deserve public confidence."

Scarce Money May Put a Crimp in Expansion Plans

Ever since the end of World War II, Wall Street investors have voiced approval of the phenomenal expansion spending of U. S. industry and of the chemical process industries in particular. And they've backed their approval with cash.

Lately, though, many of them have begun to wonder if the time hasn't come to slow down and consolidate. Outside venture capital is becoming increasingly scarce and companies are being forced to look around for new money sources.

But will this work any hardship on chemical companies? A look at the past seven years' experience shows that it might.

EARNINGS have catapulted . . .

	Fiscal Years 1945 (Millions)	1952	Percent Increase
American Cyanamid	$6.2	$26.6	329
Borden Co.	12.1	17.7	46
Union Carbide	37.8	98.3	160
Continental Oil	12.5	38.1	205
Diamond Alkali	2.9	5.5	90
Goodyear	20.2	39.0	93
Monsanto	5.6	22.8	307
Chas. Pfizer	1.9	11.4	500
A. E. Staley	2.3	3.6	57
Union Oil	9.2	27.6	200
U. S. Rubber	13.0	28.2	117

. . . BUT so have investments

	Capital Invested Since 1945 (Millions of Dollars)		
	Loans	Stock	Retained Earnings
American Cyanamid	$76.4	$52.4	$81.0
Borden Co.	45.1	none	67.8
Union Carbide	250.0	15.9	290.1
Continental Oil	4.3	25.0	109.4
Diamond Alkali	15.2	15.3	13.9
Goodyear	154.5	4.1	124.3
Monsanto	96.6	23.5	56.7
Chas. Pfizer	1.5	23.1	41.5
A. E. Staley	8.3	13.0	15.6
Union Oil	79.5	19.1	81.0
U. S. Rubber	65.7	18.3	70.6

▶ **How They Did It**—Corporate earnings have skyrocketed since 1945—$94 billion in the last five years alone. But to achieve this, corporate spending climbed to a staggering $115 billion in the same period. Here's where the money came from.

Realistic dividend policies provided $52 billion in retained earnings; depreciation and obsolescence charge-offs totaled about $30 billion. The rest, however, had to come from these two outside sources, sources that now may be drying up.

- Bank borrowings—up about $9 billion.
- Long term debts, including stocks—up almost $24 billion.

▶ **No Need to Worry**—One financial school of thought feels that industry is over the expansion hump and doesn't have to fret about finding outside money. They believe that many companies already have all the outside financing they need and that future expansion will be adequately taken care of with internal funds.

Others, though, argue that present expansion plans alone are going to require tremendous sums of new capital. A recent Commerce Dept. survey predicts that industry will spend $27 billion on new plants this year, about 2 percent more than in 1952.

And the chemical process industries are right in the thick of it. Allied Chemical & Dye Corp. is about to initiate a $200 million public-borrowing program; Gulf Oil Co. recently announced that they would spend $200 million in 1953; Eastman Kodak has budgeted $40 million for new plants and facilities this year.

But almost all these expansion programs are going to require outside financing. To get it, industry will have to convince potential investors that their fears of overexpansion are unfounded and that may well turn out to be a really tough selling job.

Outlook for Ammonia, Phenol and Ethylene Glycol

The three supply-demand patterns—shortage, balance, overage—are reflected in the market pictures of ammonia, phenol and ethylene glycol. Each presents its own problems.

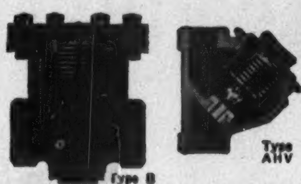
In the case of ammonia, production has fallen short of Defense Production Administration goals. Although new plants are planned, demand continues high and supply-demand balance is not being reached.

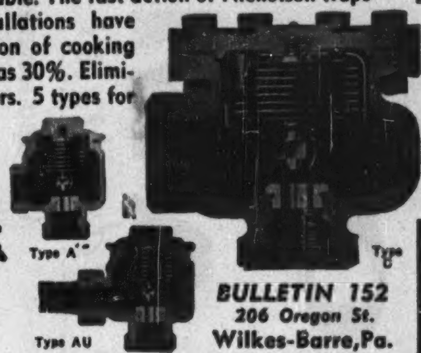
For phenol, a firm, secure, optimistic condition exists. The DPA goal seems right and new production is being scheduled at a satisfactory rate.

In the third case, ethylene glycol, it is clear that current goals have already been surpassed. Further expansion will result in excess inventories and further price cuts.

▶ **Ammonia's Short**—The tremendous upswing in the use of fertilizers accounts for most of the pyramiding demand for ammonia. The real question here is whether or not there will be enough production even when industry meets the projected DPA goal. At the end of 1952, planned expansion was over 150,000 lb. short of that goal and the likelihood of reaching the 1955 goal of 2.9 million tons seems very remote.

Over 75 percent of current ammonia production goes into fertilizers, and the Dept. of Agriculture forecasts that consumption by 1955 will be double what it was in 1950. Only recently have farmers begun to realize





ECONOMICS, *cont...*

the benefits that can be derived from the increased use of fertilizers.

Other peacetime uses of ammonia are growing, too, and in any war emergency, military requirements for explosives and propellants are bound to create industrial shortages.

▶ **Phenol's Balanced**—Despite the huge increases in phenol production—up from 15 to over 380 million lb. in the past 25 years—supply has always closely followed the demand, and so it is today. The DPA goal has been set at 623.6 million lb. by 1955 and all the necessary capacity has been accounted for by construction plans.

Major use of phenol is in phenolic resins—about 75 percent of current production. Solvent refining operations and the manufacture of chemicals from phenol take most of the rest. The Presidential Materials Policy Commission has estimated that total production will be 2,806 million lb. annually by 1975.

End Uses for Phenol (PMPC)

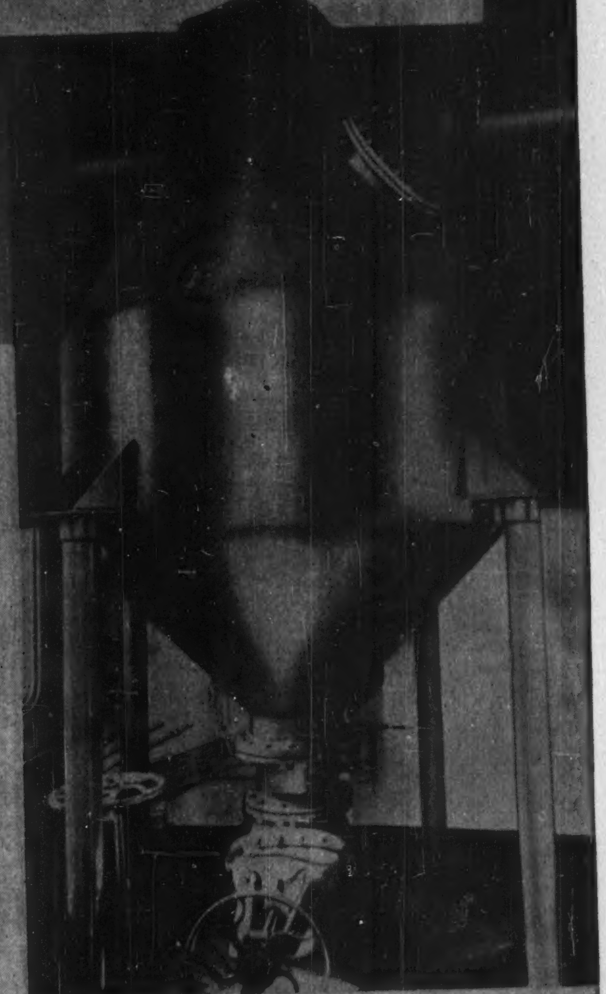
	Actual 1950	Estimated 1955	1975
	(Millions of Pounds)		
Phenolic resins......	195	400	1,950
Chemicals..........	70	148	780
Solvent refining.....	15	18	30
Export.............	14	14	14
Miscellaneous.......	17	20	32
Total..........	311	600	2,806

▶ **Ethylene Glycol's Over**—For many years ethylene glycol has enjoyed a growing market. Production reached 600 million lb. in 1951 and it all found ready users. Indications now, however, are that some of the 810 million lb. produced last year may go begging. Recent price drops reflect this situation.

Estimates of future needs are in the range of 800 million lb. by 1962. Of this, about 500 million lb. will go into anti-freeze and the remainder into synthetic fibers, detergents, etc.

Since present and indicated supplies appear to be in excess of both current and future demands, correction steps need to be taken. New facilities should be curtailed wherever possible and emphasis should be shifted to finding new uses for ethylene glycol or its precursor, ethylene oxide.

NOTE: *This analysis is based on a statement to the chemical industry by Dr. Wayne E. Kuhn, president-elect, Commercial Chemical Development Association.*—EDITOR.

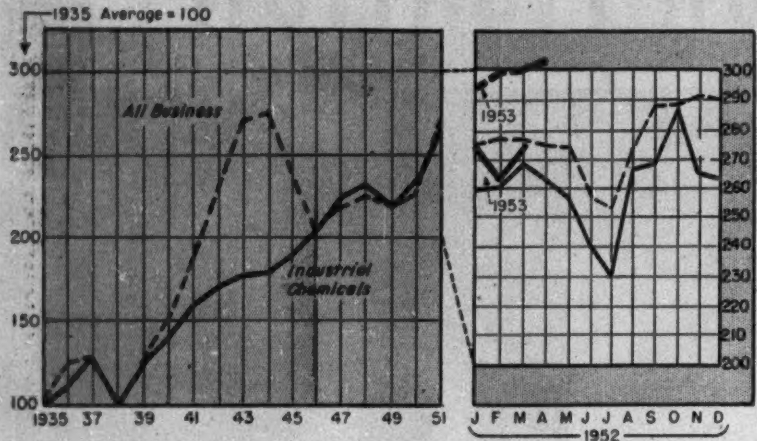


Typical Installation in Chemical Plant—150,000 CFH Deoxo Purifier

Process Industry Trends

Douglas Greenwald, McGraw-Hill Dept. of Economics

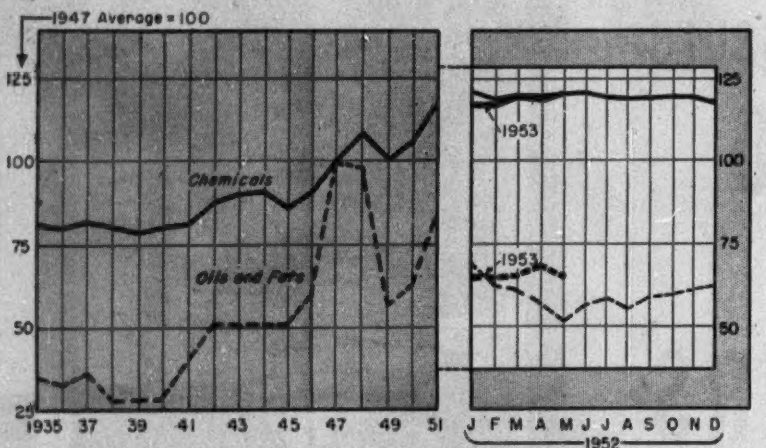
CONSUMPTION



Industrial Chemicals Index

	March (Est.)	February (Prelim.)	January (Revised)
INDEX	273.00	260.74	274.83
Fertilizer		58.48	58.35
Pulp and paper	29.14	28.47	29.95
Petroleum refining	28.32	25.52	28.40
Iron and steel	18.62	16.38	18.14
Rayon	29.72	25.17	29.86
Glass		21.20	21.68
Paint and varnish		24.05	25.86
Textiles		10.47	10.91
Coal products		10.93	12.15
Leather		4.61	4.61
Explosives		8.22	8.16
Rubber	7.32	6.48	6.84
Plastics		20.76	19.92

PRICES

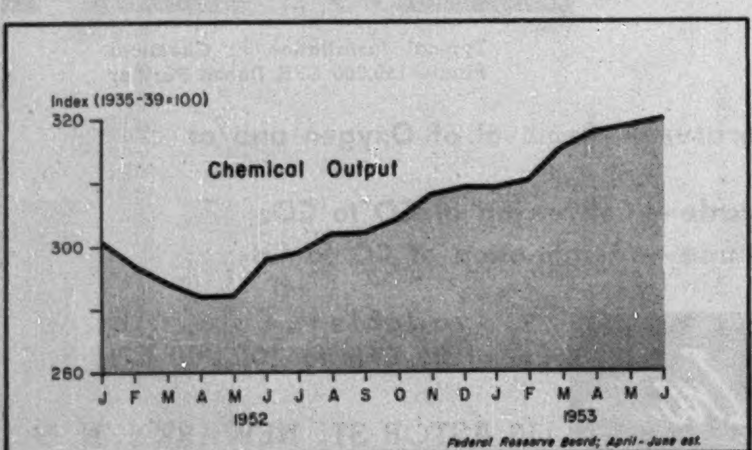


Chemical Engineering's Price Indexes

Chemicals	UP	+2.0%
Oils and Fats	DOWN	-4.9%

	Chemicals	Oils & Fats
As of May 1, 1953	120.42	64.86
Last month	118.10	68.17
May, 1952	120.21	52.00
May, 1951	119.11	93.19

HIGHLIGHT OF THE MONTH



Federal Reserve Board; April-June est.

1953 Output Is Ahead of 1952

Short-term outlook for the chemical industry is still up.

Output of chemicals, according to the Federal Reserve Board index, is running about 7 percent ahead of a year ago. Total industrial output is at a level about 10 percent over March 1952.

While chemicals continue to register gains in production, the other nondurable goods industries made little advance in March. In some cases, actual declines were recorded.

Intermediate Alloy and Stainless CROLOY Tubing Steels

B&W offers a wide range of Intermediate CROLOY and Stainless CROLOY Tubing Steels which permit utmost discrimination in selection of composition. These grades or types have different characteristics and qualities which determine their most economical specific use. Proper selection can be made only after due consideration of all factors involved in a particular application. The metallurgists, salesmen, and technical staff of B&W will welcome the opportunity to assist in the selection of the proper grade or grades best suited to meet specific conditions of service; also, B&W Bulletins TB-1, TB-6, and TB-9, containing a wealth of data on these analyses, are yours for the asking.

Analyses of the B&W Intermediate CROLOY Tubing Steels for High-Temperature Service

TYPE	CARBON	MANG.	SUL.	PHOS.	SILICON	CHROMIUM	MOLY.
CROLOY ½	0.10-0.20	0.30-0.60	0.05	0.04	0.10-0.30	0.50- 0.70	0.45-0.65
CROLOY 1	0.15	0.30-0.60	0.04	0.04	0.30	0.80- 1.10	0.45-0.65
CROLOY 1¼	0.15	0.30-0.60	0.03	0.03	0.50-1.00	1.00- 1.50	0.45-0.65
CROLOY 1¾	0.15	0.30-0.60	0.03	0.03	0.45-0.75	1.50- 2.00	0.60-0.80
CROLOY 2	0.15	0.30-0.60	0.03	0.03	0.50	1.75- 2.25	0.45-0.65
CROLOY 2¼	0.15	0.30-0.60	0.03	0.03	0.50	2.00- 2.50	0.90-1.10
CROLOY 3M	0.15	0.30-0.60	0.03	0.03	0.50	2.75- 3.25	0.80-1.00
CROLOY 5	0.15	0.30-0.60	0.03	0.03	0.50	4.00- 6.00	0.45-0.65
CROLOY 5-Si	0.15	0.30-0.60	0.03	0.03	1.00-2.00	4.00- 6.00	0.45-0.65
CROLOY 5-Ti*	0.12	0.30-0.60	0.03	0.03	0.50	4.00- 6.00	0.45-0.65
CROLOY 5-Cb*	0.12	0.30-0.60	0.03	0.03	0.50	4.00- 6.00	0.45-0.65
CROLOY 7	0.15	0.30-0.60	0.03	0.03	0.50-1.00	6.00- 8.00	0.45-0.65
CROLOY 8M	0.15	0.30-0.60	0.03	0.03	1.00	7.00- 9.00	0.90-1.10
CROLOY 9M†	0.15	0.30-0.60	0.03	0.03	1.00	8.00-10.00	0.90-1.10

NOTE: Percentages are maximum unless range is given.
*Titanium stabilized—Ti 4 x C min., 70% max.; Columbium stabilized—Cb 8 to 10 x C.
†Can also be furnished with 1.20-1.50% Mo, .50% Si—designation CROLOY 9.

Analyses of the B&W Stainless CROLOY Tubing Steels

B&W Croloy	AISI (A) Type Number	% Carbon Max.	% Manganese Max.	% Phosphorus Max.	% Sulphur Max.	% Silicon Max.	% Chromium	% Nickel	% Molybdenum	% Other Element
Croloy 18-8 H-C	302	.08-.20	2.00	.04	.03	1.00	17.0-19.0	8.0-10.0	..	..
Croloy 18-8 Si	302B	.08	2.00	.03	.03	2.00-3.00	17.0-19.0	11.0-14.0	..	..
Croloy 18-8 F-M	303	.15	2.00	.03	.04	1.00	17.0-19.0	8.0-11.0	..	Se .07-.20
Croloy 18-8 S	304	.08	2.00	.03	.03	.75	18.0-20.0	8.0-11.0	..	..
Croloy 18-12	305	.12	2.00	.04	.03	1.00	17.0-19.0	10.0-13.0	..	..
Croloy 20-10	308	.08	2.00	.03	.03	.50	19.0-22.0	10.0-12.0	..	..
Croloy 25-12	309	.08	2.00	.025	.025	1.00	22.0-26.0	12.0-15.0	..	..
Croloy 25-12 Cb	..	.08	2.00	.025	.025	1.00	22.0-26.0	12.0-15.0	..	Cb 8XC-1.00
Croloy 25-20	310	.15	2.00	.03	.03	.75	24.0-26.0	19.0-22.0	..	(B)
Croloy 16-13-3	316	.08	2.00	.03	.03	.75	16.0-18.0	11.0-14.0	2.0-3.0	..
Croloy 16-13-3 Cb	..	.08	2.00	.03	.03	.75	16.0-18.0	11.0 Min.	2.0-3.0	Cb 9XC-1.00
Croloy 18-13-3	317	.08	2.00	.03	.03	.75	18.0-20.0	11.0-14.0	3.0-4.0	..
Croloy 18-8 Ti	321	.08	2.00	.03	.03	.75	17.0-20.0	9.0-13.0	..	Ti 5XC-.60
Croloy 18-8 Cb	347	.08	2.00	.03	.03	.75	17.0-20.0	9.0-13.0	..	Cb 10XC-1.00
Croloy 12 T	403	.15	1.00	.03	.03	.75	11.5-13.0	..	..	(C)
Croloy 12 Al	405	.08	1.00	.03	.03	.75	11.5-13.5	.50 Max.	..	Al .10-.30
Croloy 12	410	.15	1.00	.03	.03	.75	11.5-13.5	.50 Max.	(D)	..
Croloy 12-2	414	.15	1.00	.04	.03	1.00	11.5-13.5	1.25-2.50	..	..
Croloy 18	430	.12	1.00	.03	.03	.75	14.0-18.0	.50 Max.	..	..
Croloy 22	443	.20	1.00	.03	.03	.75	18.0-23.0	.50 Max.	..	Cu. 90-1.25
Croloy 27	446	.20	1.50	.03	.03	.75	23.0-30.0	.50 Max.	..	N₂ .10-.25

A. For tube manufacturing reasons the analysis of the B&W Croloys may vary slightly from that of the AISI Type Number.
B. Can be furnished stabilized by addition of columbium.
C. Turbine Quality.
D. Can be furnished without or with addition of either ½ or 1 per cent molybdenum as an alloying element.

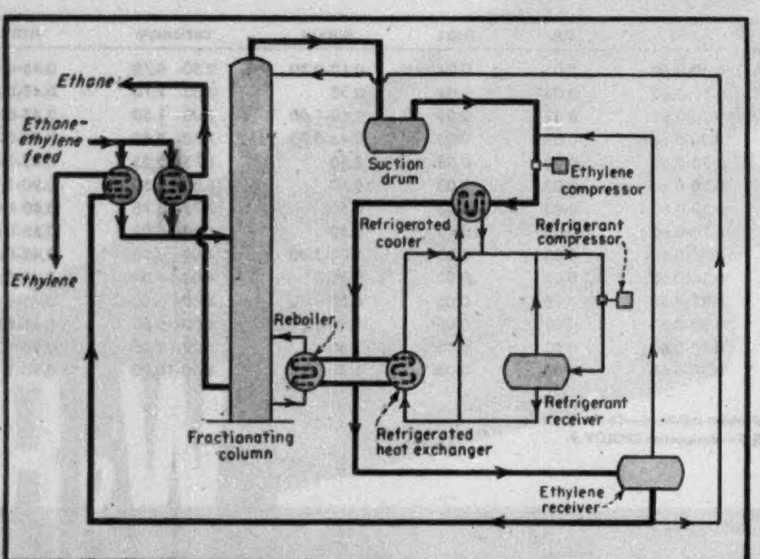
B&W SEAMLESS and WELDED TUBES

THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION

Beaver Falls, Pa.—Seamless Tubing; Welded Stainless Steel Tubing
Alliance, Ohio—Welded Carbon Steel Tubing

TA-1762-P

EQUIPMENT PATENTS



Novel Distillation System

Effective use of vapor compression in low-temperature fractionation reduces the number of trays needed to separate close-boiling compounds.

Better thermodynamic efficiency, reduced pressure requirements and a smaller column with fewer trays! These are the major claims James E. Gantt makes for his new distillation process.

The method uses vapor compression techniques and is particularly useful in the separation of close-boiling volatile components where the overhead has to be refrigerated in order to provide reflux. The only limitation is that temperatures not be so low as to require "deep refrigeration."

Gantt's process involves the compression of overhead vapors to a temperature and pressure high enough to allow their use as a heating agent in the column reboiler. The compressed vapors give up their latent heat in the reboiler, evaporate bottoms for the vapor return to the column and are themselves partially condensed.

After passing through an expansion valve, they provide overhead product and liquid reflux for the column. Additional cooling, if needed, is provided by an external refrigerated cooler, preferably before the reboiler-condenser, so that refrigeration is accomplished at a relatively high temperature level.

▶ **Sample Use**—A typical application of this system is in the separation of ethane-ethylene mixtures (see *cut*). Here the charge mixture enters at about 200 psig. and is cooled to about −20 deg. F. by heat exchange with each of the two cold products.

The column operates at 200 psig. with a bottoms temperature of 0 deg. F. and a top temperature of −35 deg. F. Overhead vapor goes to a compressor which raises the pressure from 200 to about 550 psig. and the temperature to 100-150 deg. F.

The ethylene stream, with heat of compression, passes to a refrigerated cooler (after water-cooling, if necessary) and leaves at about 60 deg. F. It then goes to the column reboiler where further cooling and condensation occur. Additional refrigeration can be applied in another refrigerated heat exchanger at this point.

The cooled liquid next passes through a reducing pressure valve to the ethylene receiver. It is now at about 250 psig. and 25 deg. F. Part of the stream is used as reflux, the rest as product.

Any vapor formed in the receiver is recycled to the ethylene compressor. Normally only a single compression stage is needed, eliminating the need for reflux and bottoms pumps.

The patent (U.S. 2,629,239) has been assigned to Universal Oil Products Co.

Alternate Hot and Cold Zones Give Fractional Sublimation

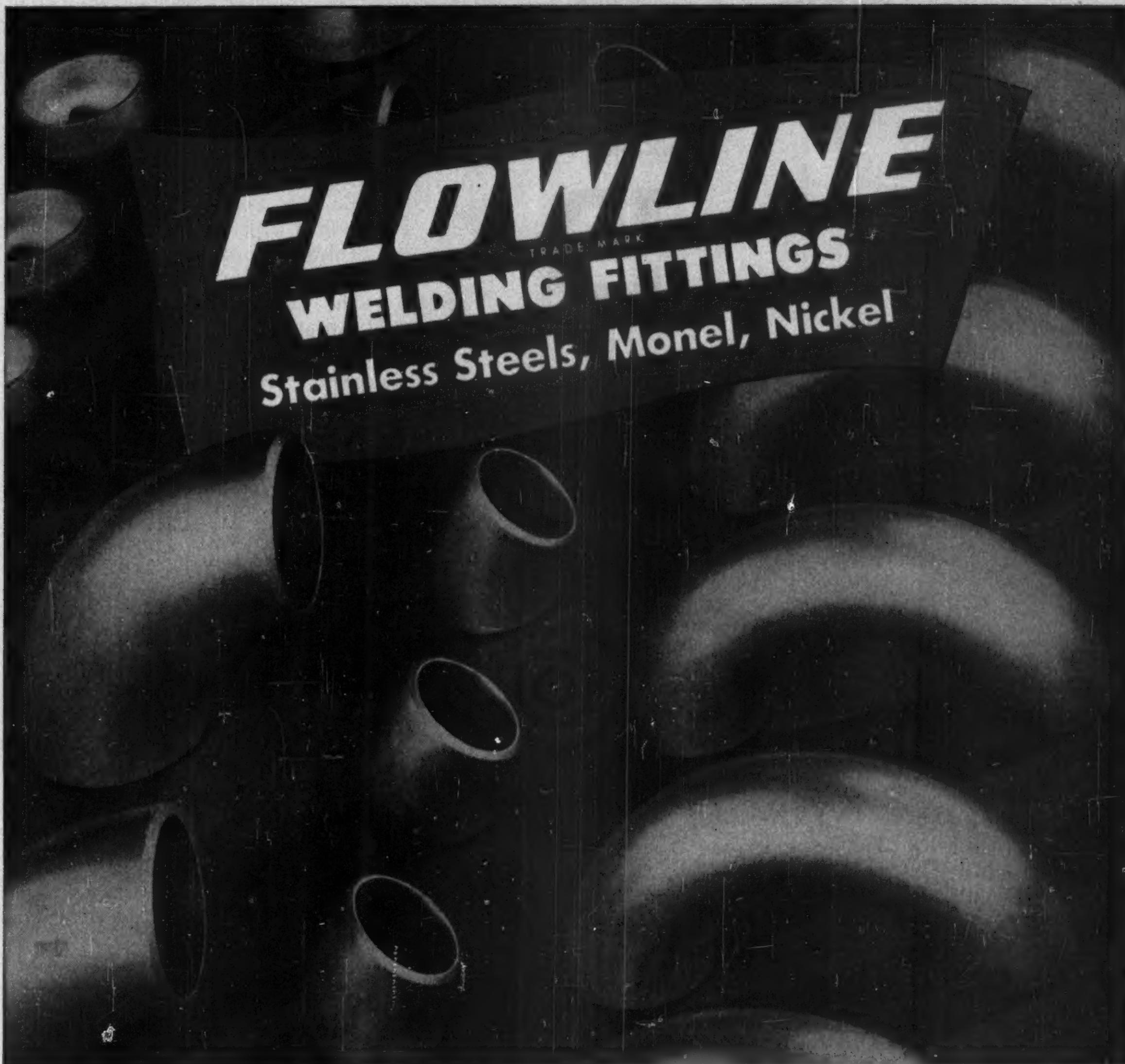
In a new device, by Allen Francis Reed, alternate vaporization and condensation in heating and cooling zones is used to accomplish fractional sublimation. Reed has assigned his invention (U.S. 2,628,892) to the United States of America as represented by the Atomic Energy Commission.

In operation, one part of the material vaporized in each heated zone is caused to flow back, countercurrent to the condensed phase, as vapor "reflux" which is partially condensed in the next preceding zone. The remainder of the vaporized material is caused to flow forward to the next cooled zone where it also is partially condensed.

The mixture to be separated is admitted to a horizontal helical tube which is alternately heated and cooled along its length. Solid condenses in the cold zones. The alternate hot and cold zones are then moved relative to the condensed mixture toward the point of admittance by slowly rotating the helical tube.

The body of the condensate thus gradually leaves a cold zone and simultaneously advances into an adjacent hot zone where it is progressively sublimed. The vapor formed is enriched with respect to one of the components because of the difference in vaporization rates of the components.

Cooling zones are established simply by allowing the bottom part of



3000 Stock Items Made by Corrosion-Resistant Specialists

The makers of FLOWLINE Welding Fittings were the first to standardize, manufacture, and stock a complete line of welding fittings for corrosion piping. These fittings are handled by leading distributors throughout the country who are experts in corrosion piping problems.

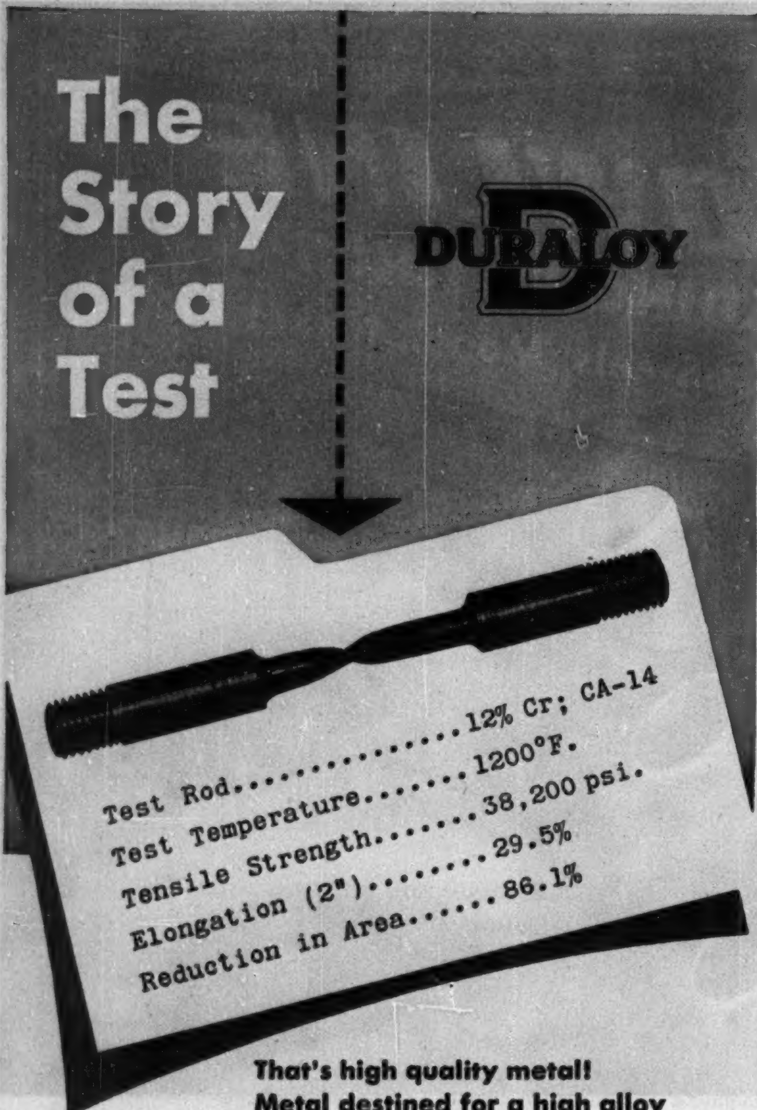
The most economical and efficient corrosion-resistant piping system is obtained by using FLOWLINE Fittings. Any conceivable layout can be constructed with them simply by straight cutting of pipe to desired lengths and plain butt welding. The advantages include minimum initial cost and faster fabrication of a compact, light weight and strong system which is permanently leak-proof and has best flow characteristics.

FLOWLINE Welding Fittings — ells, tees, stub ends, reducers, and caps — are normally stocked at strategic points in Schedules 10, 40, and 80 (Schedule 5 also available) — sizes ½" through 12" — in stainless types 304, 316, and 347; Monel and Nickel. They are annealed, cleaned bright — stainless fittings are passivated — and marked with type of metal, heat number, size, schedule, and wall thickness.

WELDING FITTINGS CORP.

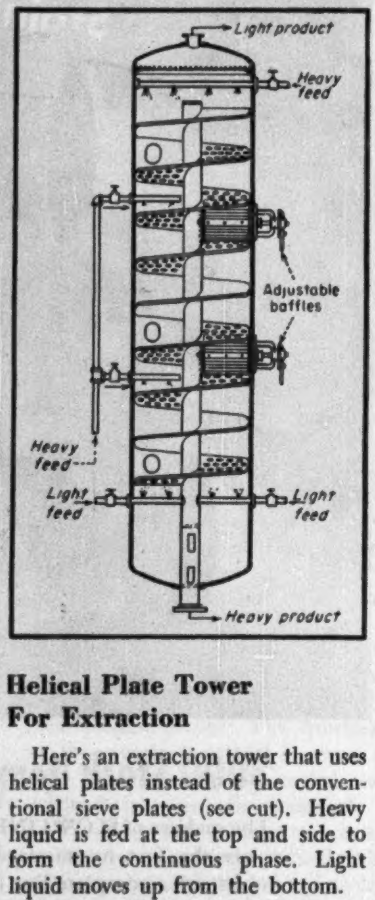
NEW CASTLE, PENNSYLVANIA

World's Largest Manufacturer of Stainless Welding Fittings



the helical coil to dip into a refrigerating bath; heating zones are provided by heating the upper part of the coil.

Operation is batchwise, starting with the entire charge condensing in the cold sections of the tube. Rotation at 1 rpm. is started and the more volatile component moves to the discharge end to a greater degree than the less volatile constituent, thereby providing the desired enriching effect.

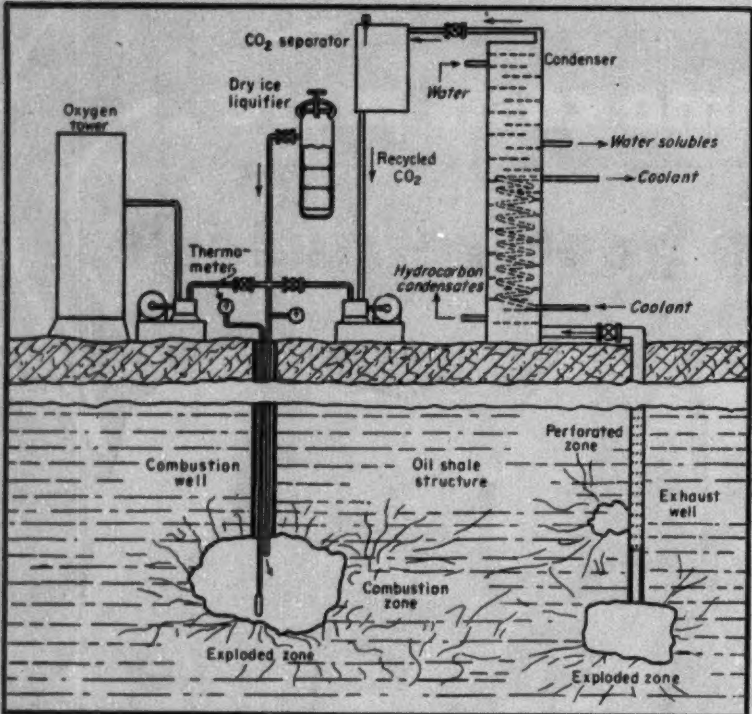


Helical Plate Tower For Extraction

Here's an extraction tower that uses helical plates instead of the conventional sieve plates (see cut). Heavy liquid is fed at the top and side to form the continuous phase. Light liquid moves up from the bottom.

The heavy liquid travels down the helix while the light material can move either along the helix or through perforated holes in it, thus providing necessary mixing. Non-perforated flights of the helix are located between groups of perforated flights and constitute the settling zones.

George J. Langmyhr describes the device in U.S. 2,628,894 and claims that rotation along the helix aids in separating the mixed liquids by centrifugal force. Adjustable baffles are used to vary the ratio of flow through the perforations to that along the helix.



VERTICAL WELLS for deep deposits.

New Ways to Retort Oil Shale

Here are two new methods for retorting oil shale underground. A better grade of crude oil at lower costs is claimed by both inventors.

Although big strides have been made in oil shale retorting in the last five years, conventional methods still involve cumbersome and expensive equipment and high operating costs. Poor heat recovery in the retorting systems and the expense of mining, crushing and handling the shale have been major economic burdens on the processes.

Now two men have come up with retorting systems specifically designed to overcome these difficulties. Both methods do the job underground, automatically eliminating mining, handling and crushing. And both men claim higher quality crude oil.

• In U.S. 2,630,037 by James W. Martin, a combustion-supporting gas containing a critical ratio of CO_2 to O_2 is used (see cut above).

Oxygen and CO_2 are fed into a combustion well. Combustion occurs in a previously exploded area, ignition being supplied by an electric spark or by thermite. Sufficient pressure builds up to force the products of combustion and distillation through the oil shale structure to an outlet well which may be 50 ft. away.

The hot combustion gases, passing through the shale, distill out the hydrocarbons. Coke remaining as residue in the shale is gradually burned away by the oxidizing gases.

The oil is condensed in a water-cooled condenser, water-soluble materials being removed higher up in the condenser. Fixed gases are then separated from the condenser vent gases and some of the CO_2 is recycled.

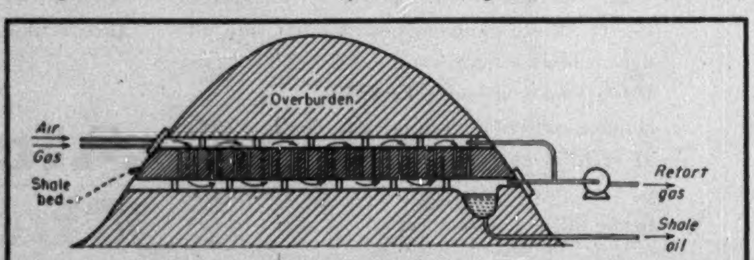
The objection to the use of air is that the resulting vapors are greatly diluted with nitrogen. The objection to the use of pure oxygen is that it produces excessive temperatures which lead to slagging of the shale—thereby sealing off the pores in the strata—and also to breakdown of the product.

In Martin's method, which has been assigned to Carbonic Products, Inc., the temperature in the combustion zone is kept below 1,000 deg. C. to limit the formation of carbon monoxide. The temperatures in the zones of destructive distillation are kept at about 500 deg. C. by regulating the ratio of CO_2 to O_2. It has been found that the best results are obtained when the flue gases contain more than 80 percent carbon dioxide.

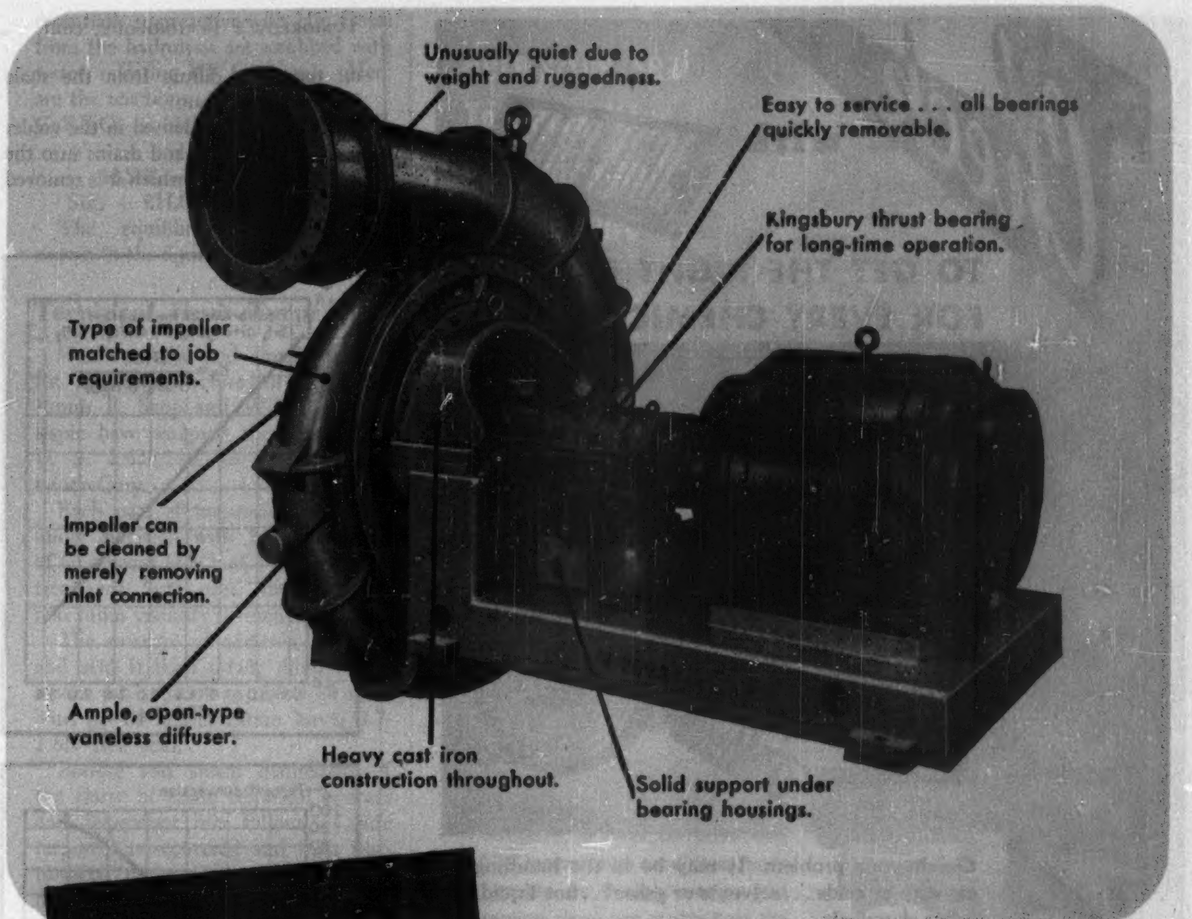
• In U.S. 2,630,306 by Louis P. Evans, and assigned to Socony-Vacuum Oil Co., a combustion-supporting gas such as air, or air and recycle gas, is blown alternately up and down through a series of vertical holes (see cut below).

Horizontal tunnels are first driven above and below the oil-bearing shale strata. Then a series of vertical holes are drilled through the shale to connect the two tunnels. Baffles are placed at intervals in the tunnels to direct the flow of gas.

Retorting takes place in the shale bed by ignition in the first series of vertical holes. Combustion-supporting gas is passed through and liberates enough heat to intitiate retorting in the subsequent zones, thereby causing

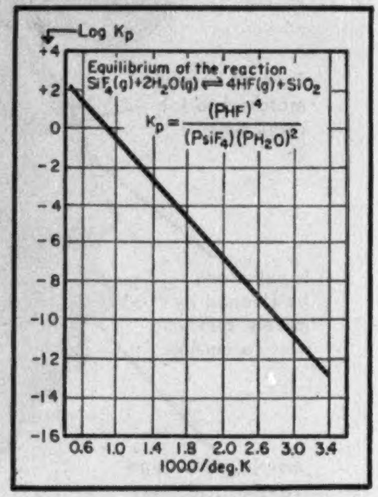


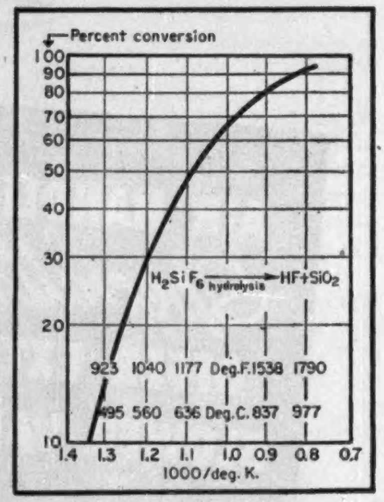
HORIZONTAL TUNNELS for dome deposits.


Unusually quiet due to weight and ruggedness.
Easy to service . . . all bearings quickly removable.
Kingsbury thrust bearing for long-time operation.
Type of impeller matched to job requirements.
Impeller can be cleaned by merely removing inlet connection.
Ample, open-type vaneless diffuser.
Heavy cast iron construction throughout.
Solid support under bearing housings.

oil vapors to diffuse from the shale into the gas stream.

Shale oil is condensed in the colder zones downstream and drains into the lower tunnel, from which it is removed through conduits.





New Production Method for Calcium Fluoride and Silica

In U.S. 2,631,083, by George E. Engelson and Robert N. Secord, assigned to Godfrey L. Cabot, Inc., high purity calcium fluoride and silica are produced from siliceous fluorspar.

The fluorspar is reacted with HF, silica combining with the acid to form fluosilicic acid. CaF_2 is separated, the fluosilicic acid is vaporized and the vapors are hydrolyzed to silica at high temperatures.

The silica is separated from the HF at a temperature at which silica is

essentially nonreactive with HF. Gases from the hydrolysis are scrubbed with water, releasing HF for recycle. Here are the reactions:

$$CaF_2SiO_3 + 6HF \rightarrow CaF_2 + H_2SiF_6 + 2H_2O$$

$$H_2SiF_6 \rightarrow SiF_4 + 2HF$$

$$SiF_4 + 2H_2O \rightarrow SiO_2 + 4HF$$

The equilibrium conversion is shown in the figures above.

Terpineol from Turpentine

Here's a new and simple process for the manufacture of terpineol. Junius E. Sapp and Wilbur F. Gillespie have assigned their invention, U. S. 2,628,258, to Gaylord Container Corp.

Each part of turpentine is treated under agitation with 1.08-2.88 parts of 60 percent H_2SO_4 at 5 deg. C. This treatment lasts until the mixture's maximum viscosity is reached, 1½-3 hr.

The mixture of addition products and acid is then slowly diluted into a soda ash solution in about 30 min. This partial neutralization leaves 0.7-2.6N free acid.

Boiling and steam distillation of the slurry of crude terpineol hydrate and byproduct oils follows. Crude terpineol is recovered and then fractionated under vacuum to yield refined terpineol.

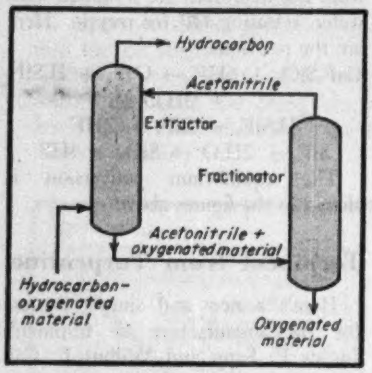
Manufacture of Phenols

Three patents have been issued recently on the manufacture of phenols. Two are assigned to Hercules Powder Co. (U.S. 2,628,983 and 2,628,984); the third (U.S. 2,628,985) is assigned to Shell Development Co.

• The Hercules patents are by B. V. Aller, R. H. Hall, D. C. Quin and K. W. H. Turck. Their method involves the liquid-phase oxidation of an alkyl benzene such as isopropyl benzene to give the peroxide. The oxidation is stopped after about 50 percent conversion in order to minimize the danger of explosion.

Free peroxide is extracted with alkali from the unreacted benzene. It is then acidified and decomposed by refluxing with 10 percent sulfuric acid, producing phenol and acetone.

• The Shell method, by De Loss E. Winkler and Harry de V. Finch, uses catalytic dehydrogenation of cyclohexanone and cyclohexanol to produce phenol. The catalysts are of the iron oxide type and contain some potassium and chromium oxides.



Extraction of Hydrocarbons From Oxygenated Materials

This new process by William I. Denton and Richard B. Bishop is a solvent extraction method for the separation of hydrocarbons from oxygenated compounds of like boiling point obtained in synthesis reactions. Acetonitrile is used as the selective solvent (see cut).

Ratios of acetonitrile to feed are between 1:1 and 5:1; temperatures range from room temperature to 80 deg. C. at atmospheric pressure. Small amounts of water may also be added in certain cases.

The patent (U.S. 2,629,730) has been assigned to Socony-Vacuum Oil Co., Inc.

Separation of Ethylbenzene From Xylene Fractions

C_8 aromatic hydrocarbon fractions consisting of ethylbenzene and xylenes can be separated with boron trichloride according to Carl B. Linn in U.S. 2,630,406. He has assigned his invention to Universal Oil Products Co.

One volume of the aromatic fraction is mixed with 0.2-2.0 liquid volumes of trichloride and the mixture is fractionally distilled. Since the boron trichloride boils at 13 deg. C., the mixing is done in a closed, suitably cooled vessel under pressure. The overhead from the process is rich in ethylbenzene. Water washing removes boron trichloride from the distillate.

Boron trichloride can also be used to separate benzene from cyclohexane by extractive distillation.

Copies of all patents can be ordered from the Commissioner of Patents, Washington 25, D. C. They cost 25¢ each. Do not send stamps.

Your Checklist of New Equipment Patents

Operation . . .	About . . .	Inventor or Assignee . . .	Patent No. . .
Adsorption	Regeneration of spent adsorbents	California Research Corp.	2,628,933
	Continuous adsorption separation of gases	Union Oil Co. of California	2,630,876-7
Crushing and Grinding	Pulverizing solid particles by attrition in an electromagnetic field	George A. Fink	2,628,785
	Moving-fluid-stream pulverizer with screened exit	Celanese Corp. of America	2,628,786
	Gyratory crusher	John R. and Donald Kueneman	2,628,788
Drying	Drying of solids in a fluidized bed	Kaiser Aluminum & Chemical Corp.	2,629,938
Electrolysis	Mercury cathode electrolytic cell	Allied Chemical & Dye Corp.	2,631,126
Extraction	Horizontal counterflow liquid-liquid extractor	Shell Development Co.	2,629,654
	Multiple extractor	University of California	2,630,376
	Continuous leaching apparatus	Susan S. Rasmussen, Emilie G. Jensen, Phillip H. Mallinckrodt and Phillip A. Mallinckrodt	2,630,377
Filtration	Filter cloths for alkaline aqueous liquids	Metakloth Co.	2,631,110
Flotation	Apparatus for aerating flotation pulps	Mining Process & Patent Co.	2,628,827
Fluid and Particle Transfer	Oil diffusion pump for high vacuum	National Research Corp.	2,630,266
	Injector for fluidized beds	The M. W. Kellogg Co.	2,630,352
Gas-solids Separation	Disengagement of gases from a moving bed of fluidized solid particles	Houdry Process Corp.	2,628,893
	Removal of gas from fluidized solid particles	Standard Oil Development Co.	2,629,653
Heat Exchange	Heater for asphalt and tars in tank cars	John F. Seevers	2,629,366
	Pebble heater and regenerator	Phillips Petroleum Co.	2,630,413
Instrumentation	Moisture content recorder for gases under pressure	United States of America	2,629,253
	Differential refractometer	Dominion of Canada	2,630,042
	Viscosity controller	Austin S. Norcross	2,630,819
	Gas analyzer	Lloyd V. Guild	2,631,088
Liquid-solids Separation	Centrifugal separator	Samuel L. Abbott	2,630,268
Liquid-vapor Contacting	Tower packing	Pan American Refining Corp.	2,630,305
Reactors	Moving bed catalytic converter for hydrocarbons	Universal Oil Products Co.	2,629,684
	Mixer for continuous polymerization	Celanese Corp. of America	2,630,302
	For conversion operations with fluidized solids	Standard Oil Development Co.	2,631,089-90
	High-pressure contactor	Standard Oil Co. (Ind.)	2,631,091
Storage	Gas holder	John W. Allen	2,631,093

. . . And New Process Patents

Product . . .	Process . . .	Inventor or Assignee . . .	Patent No. . .
Carbon Black	Apparatus for producing impingement carbon black	Godfrey L. Cabot, Inc.	2,628,891
Catalysts	Iron catalyst for hydrogenation of CO	Ruhrchemie Aktiengesellscaft	2,628,969
	Iron nitride catalyst in carbon oxide hydrogenation	United States of America	2,629,728
	Preparation of alumina-halogen-platinum catalyst	Universal Oil Co.	2,631,136
Essential Oils	Separation of essential oils into component fractions by solvent extraction	Donald F. Othmer, Morris B. Jacobs and Nathan Wishnefsky	2,631,145
Fats, Oils and Soaps	Partial esters from glycerol and fatty acids	The Givaudan Corp.	2,628,967
	Winterizing of glyceride oils	Swift and Co.	2,631,156
	Fractionation of tri-glycerides	The Chemical Foundation, Inc.	2,631,157
Hydrocarbons	Separation of naphthenes from hydrocarbon mixtures	Standard Oil Development Co.	2,628,990
	Isomerization of paraffins with aluminum halides	Phillips Petroleum Co.	2,629,754
Inorganic Chemicals	Calcination of limestone	Basic Refractories, Inc.	2,628,829
	Electrolytic production of chlorates	The Pennsylvania Salt Manufacturing Co.	2,628,935
	Purification of phosphate rock containing iron	International Minerals & Chemicals Corp.	2,629,650
	Spent acid restoration	Standard Oil Development Co.	2,629,747
	Vanadium extraction from vanadium-tungsten ores	Climax Uranium Co.	2,630,369
	Manufacture of magnesium carbonate	Merck & Co., Inc.	2,630,371
Metals	Electro-deposition of chromium	Research Corp.	2,630,407
Organic Chemicals	Production of hydroxylamine and its acid salt	E. I. du Pont de Nemours & Co.	2,628,888-9
	Process for making stabilized diazonium salts	General Aniline & Film Corp.	2,628,959
	Preparation of olefin oxides	General Aniline & Film Corp.	2,628,965
	Production of concentrated formic acid	Norsk Hydro-Elektrisk Kvaelstofaktieselskab	2,628,976
	Preparation of unsaturated aldehydes	N. V. Organon	2,628,979
	Purification of isopropanol	Shell Development Co.	2,628,986
	Manufacture of fluoro-olefins	Allied Chemical & Dye Corp.	2,628,989
	Flotation of guanadine salts	American Cyanamid Co.	2,629,492
	Purification of butane-diol	General Aniline & Film Corp.	2,629,686
	Heterogeneous acidic hydrolysis of polymeric esters	E. I. du Pont de Nemours & Co.	2,629,713
	Preparation of organosiloxanes	Dow Corning Corp.	2,629,725-7
Pigments	Production of titanium dioxide pigments	American Cyanamid Co.	2,628,919
	Preparation of acid-resistant ultramarine pigment	American Cyanamid Co.	2,628,920
Resins and Plastics	Thermoplastic resins formed from pinewood pitch	Valite Corp.	2,628,917
	Production of vinyl chloride-styrene polymers	The B. F. Goodrich Co.	2,628,957
	Halo-methylated vinyl-aromatic copolymers	Charles H. McBurney	2,629,710
	Xanthation processes	E. I. du Pont de Nemours & Co.	2,629,714-5
	Preparation and hydrolysis of cellulose acetate	E. I. du Pont de Nemours & Co.	2,629,716
Rubber	Manufacture of lap-resistant synthetic rubber	Armstrong Cork Co.	2,629,707
	Emulsion polymerization of vinylidene compounds	Phillips Petroleum Co.	2,629,708-9
	Method of plasticizing rubber	E. I. du Pont de Nemours & Co.	2,629,755
Sulfur Compounds	Production of noncaking, finely-divided sulfur	Mathieson Chemical Corp.	2,629,133
	Manufacture of sulfuric acid	Allied Chemical & Dye Corp.	2,629,651
	Manufacture of flake sulfur	Jefferson Lake Sulphur Co.	2,629,895
	Recovery of sulfur from gases containing H_2S	Jefferson Lake Sulphur Co.	2,630,374-5
	Production of granular ammonium sulfate	Phillips Petroleum Co.	2,631,084
	Sulfur recovery from acid sludge	The Fluor Corp., Ltd.	2,631,087
Synthesis Gas and Processes	Reduction of carbon formation in syntheses	Standard Oil Development Co.	2,628,968
	Synthesis of liquid hydrocarbons	Hydrocarbon Research, Inc.	2,628,970
	Hydrocarbon synthesis	Hydrocarbon Research, Inc.	2,629,729
	Generation of synthesis gas	Texaco Development Corp.	2,630,378
	Preparation of olefins by synthesis	Michael Steinschlaeger	2,630,447
	Conversion of natural gas to hydrogen and CO	Standard Oil Co. (Ind.)	2,631,094
	Synthesis of liquid hydrocarbons	Hydrocarbon Research, Inc.	2,631,159
Synthetic Fibers	Production of artificial thread from viscose	Courtaulds, Ltd.	2,628,885
	Production of artificial polymeric fibers	Courtaulds, Ltd.	2,628,886
	Preparation of acrylonitrile polymers	Eastman Kodak Co.	2,629,711-2

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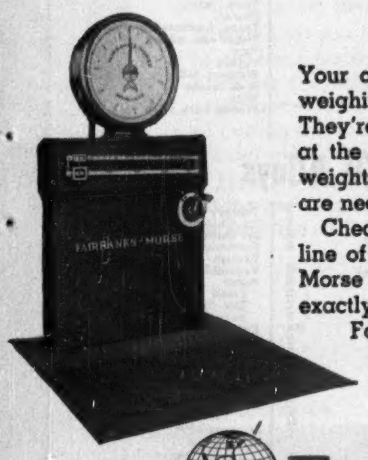

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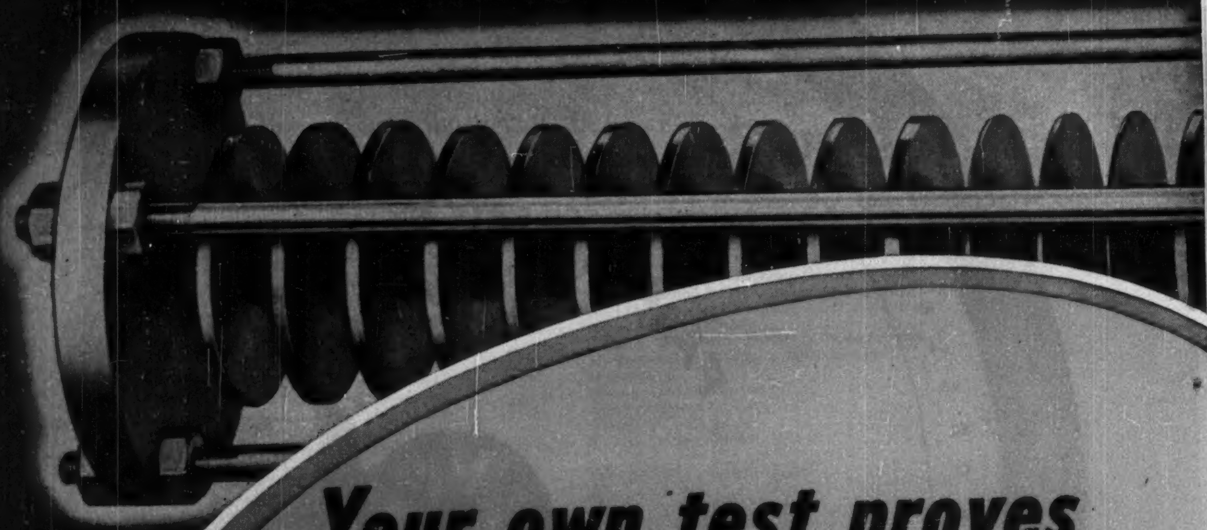

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Bearings
Beater bars
Bellows
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Brazing rod
Brine coils
Bubble caps and trays
Calendrias
Condenser shells

Condenser tubes
Condenser tube sheets
Control valves
Conveyors
Coolers
Crystallizers
Dephlegmators
Digestors
Ejectors
Evaporators
Evaporator tubes
Extractors
Fabricated assemblies
Filters and filter screens
Filter presses

Fittings — forged, cast
Forgings
Fractionating columns
Hangers
Heat exchangers
Heater coils
Hooks
Injectors
Instrument cases and elements
Kettles
Line hardware
Motor cases
Mixers
Pans, evaporator

Perforated plate
Pickling baskets
Pipe and fittings
Plug cocks
Pressure vessels
Pumps
Reboilers
Retorts
Rivets
Safety tools
Screens
Screws, conveyor
Sludge burners
Springs
Stills

Studs
Sucker rod
Tanks
Tools, safety
Towers
Trays, fractionating
Tubes and tubing
Vats
Valves
Welding rod
Well tubing
Wire
Woven wire cloth

Chemical Agents and the Applicability of AMPCO Alloys

Acetate Solvents (Pure)
Crude
Acetic Acid
Crude
Vapors
Acetic Anhydride
Acetone
Acetylene
Alcohols
Aluminum Fluoride
Aluminum Sulfate
Aluminum Hydroxide
Ammonia Gas
Dry
Wet
Ammonium Chloride
Ammonium Hydroxide
Ammonium Nitrate
Ammonium Phosphate
Ammonium Sulfate
Amyl Chloride
Asphalt
Barium Chloride
Beer
Beet Sugar Liquors
Benzene or Benzol
Borax
Boric Acid
Brine
Butane, Butylene
Butadiene
Butyric Acid
Calcium Bisulfite
Calcium Hydroxide
Calcium Hypochlorite
Cane Sugar Liquors
Carbolic Acid

Carbon Dioxide
Dry
Wet
Carbon Disulfide
Carbon Tetrachloride
Caustic Soda
Chlorine
Dry
Wet
Chloroform
Chromic Acid
Citric Acid
Copper Sulfate
Crude Oils — Sour
Esters
Ethers
Ethylene Glycol
Ethyl Sulfate
Ferric Chloride
Ferric Sulfate
Formaldehyde
Formic Acid
Freon
Furfural
Gasoline
Gelatine
Glucose
Glycerine
Hydrocarbon Gases
Hydrochloric Acid
to 5%
to 10%
(see Muriatic)
Hydrocyanic Acid
Hydrofluoric Acid
Hydrogen Fluoride (Dry)
Hydrogen
Hydrogen Peroxide

Hydrogen Sulfide
Wet
Dry
Lacquers and Lacquer Solvents
Lactic Acid
Magnesium Chloride
Magnesium Hydroxide
Magnesium Sulfate
Malt Beverages
Mercuric Chloride
Mine Water (Sulfate)
Molasses
Monochlorobenzene
Muriatic — Conc. Commercial
Naptha
Natural Gas
Nickel Chloride
Nickel Sulfate
Nitric Acid
Nitrogen (Dry)
Oleic Acid
Oxygen
Paint Vehicles (Except Soya-Oil)
Palmitic Acid
Petroleum Oils
Sour
Refined
Phenol
Phosphoric Acid
Pickling Acid (except Nitric Chromic)
Potassium Chloride
Potassium Cyanide
Potassium Hydroxide
Potassium Sulfate

Potash Crudes
Propane
Shellac
Soaps
Soda Ash (Sodium Carbonate)
Sodium Bicarbonate
Sodium Bisulfate
Sodium Carbonate
Sodium Chloride
Sodium Cyanide
Sodium Hydroxide
Sodium Nitrate
Sodium Perborate
Sodium Peroxide
Sodium Phosphate
Alkaline
Neutral
Acid
Sodium Silicate
Sodium Sulfate (Soda Cake)
Sodium Sulfide
Sulfur
Sulfur Chloride
Sulfur Dioxide
Dry
Wet
Sulfuric Acid
5%)
10%)
25%) Up to Boiling
35%)
50%)
Sulfuric Acid Sludge
Sulfurous Acid
Tannic Acid
Tartaric Acid

Toluene or Toluol
Tri Chlorethylene
Tri Sodium Phosphate
Turpentine
Varnish
Vegetable Oils
Water
Fresh
Salt (Includes Polluted Harbor)
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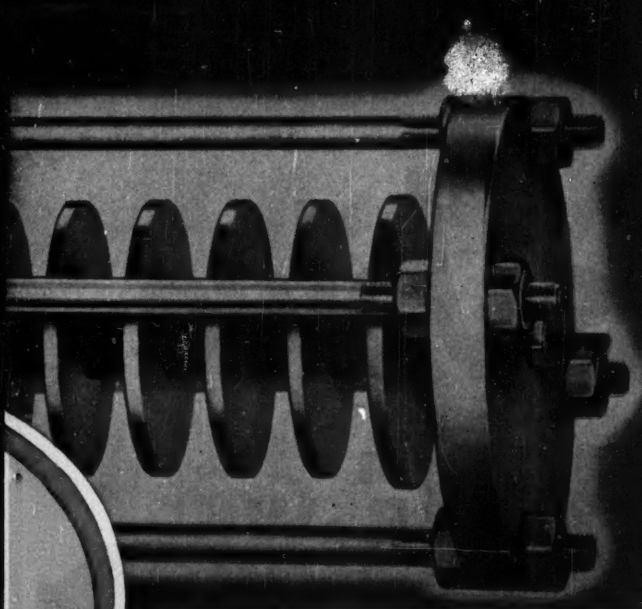
F — Fair IPY Penetration < 0.050"
NR — Not Recommended IPY Penetration Over 0.050"

In using this data, it should be understood that these are results of specific tests and are indicative of those conditions under which the tests were run, and are a basis for recommendation, but not for guarantee.



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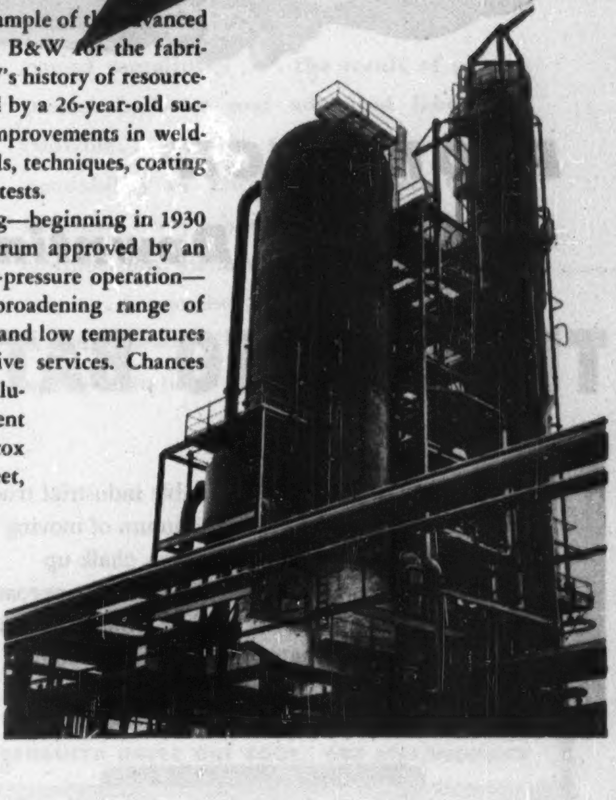

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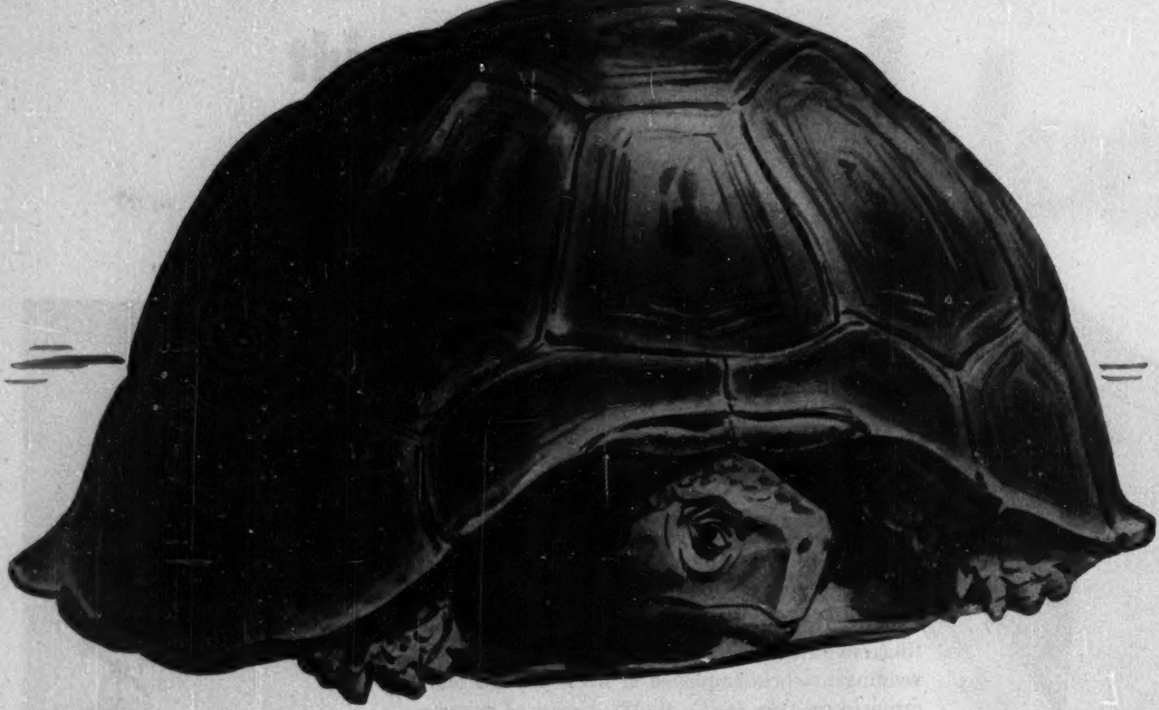

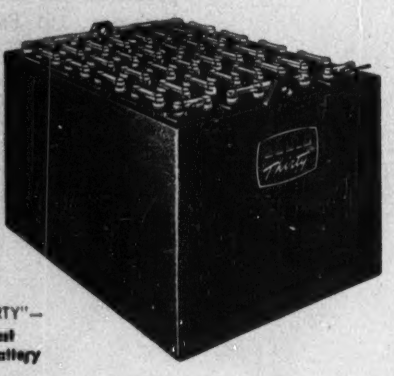

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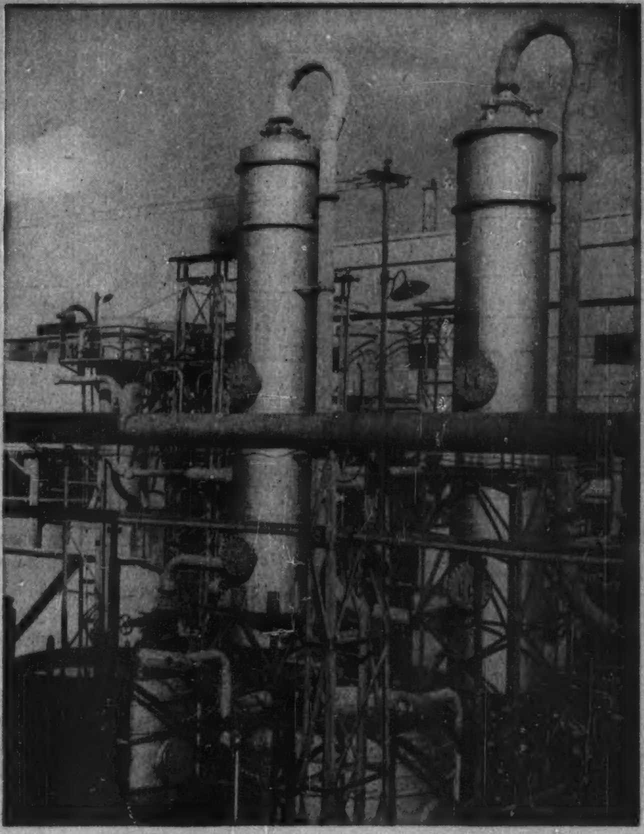

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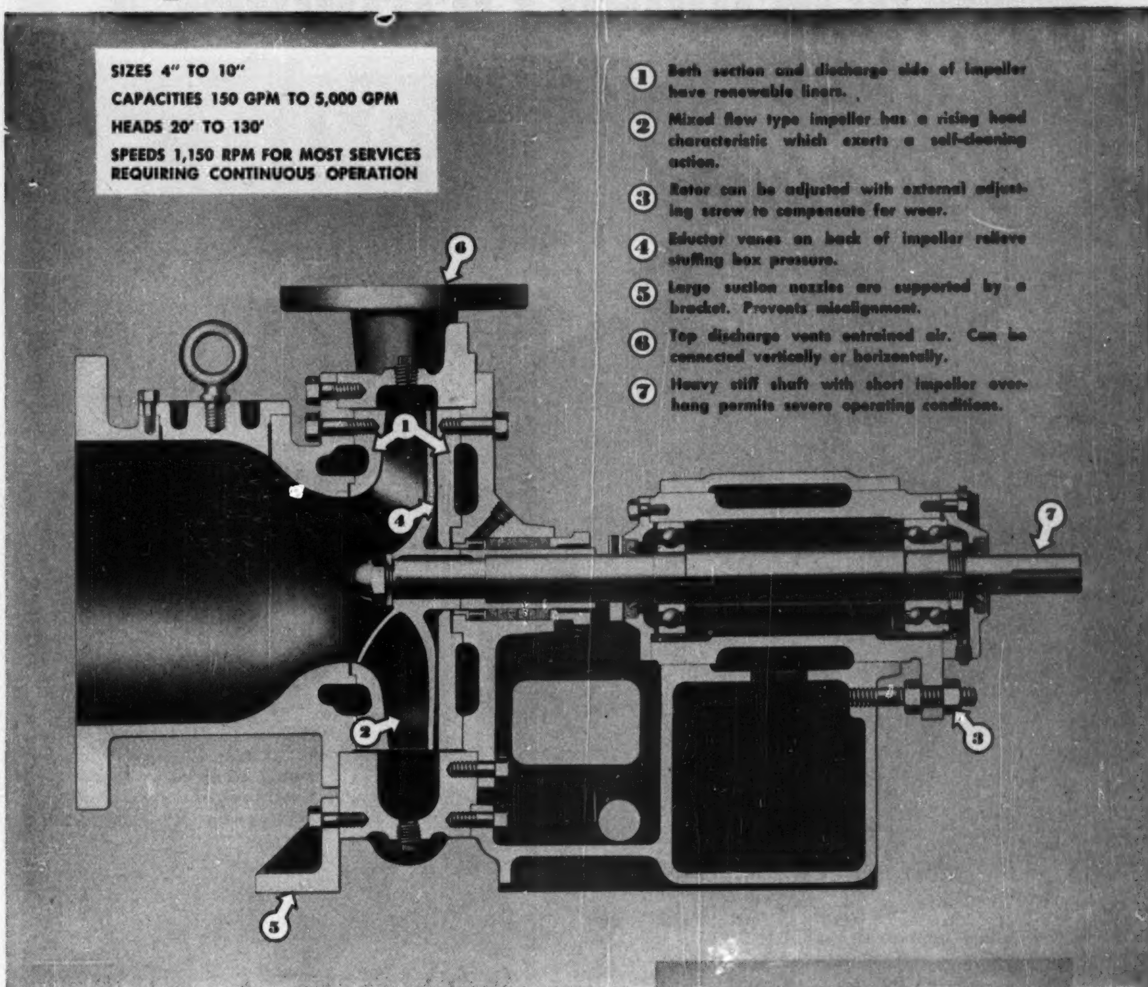

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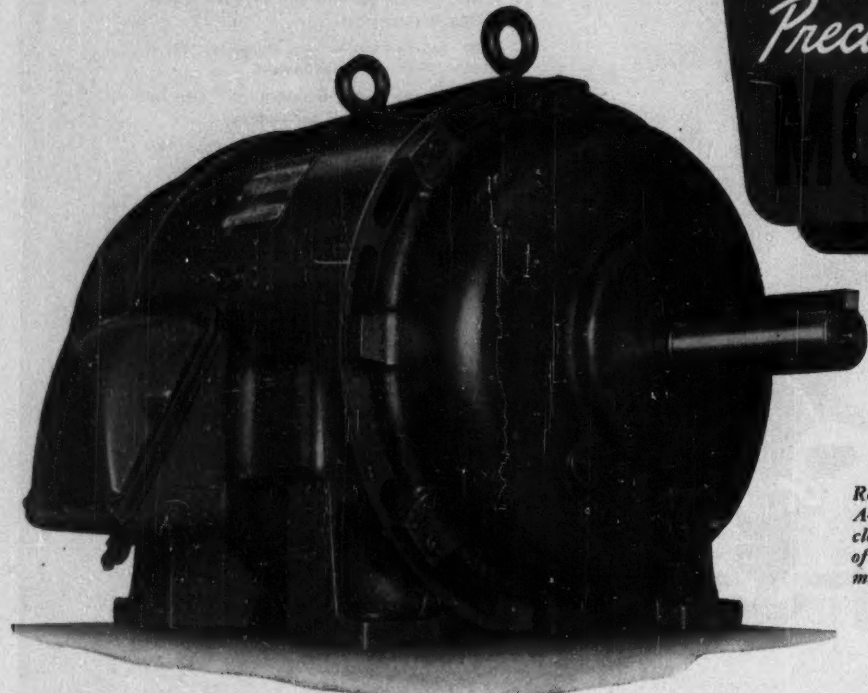
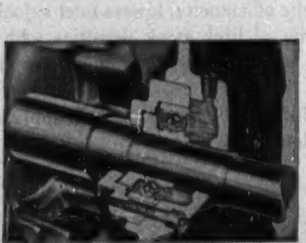
RELIANCE *Precision-Built* MOTORS



Reliance Totally-enclosed Fan-cooled A-c. Motor. All other standard enclosures available, with wide choice of mechanical designs and special mountings. Ratings from 3/4 to 300 hp.

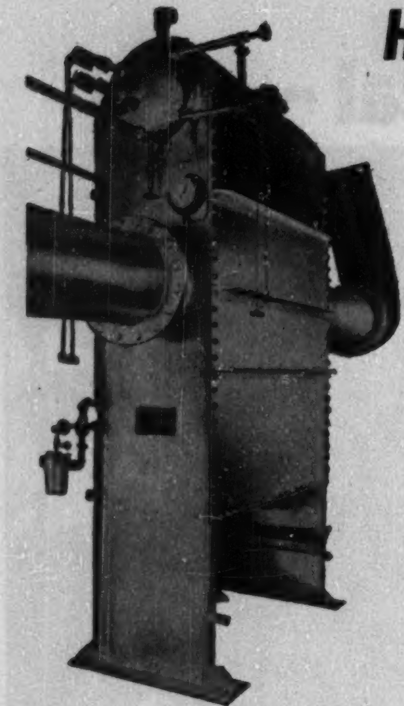
- **Corrosion-resistant frame and bearing brackets**
- **Tough, chemical-resistant Reli-X insulation**
- **Heavy shafts, bearing to bearing**



. . . AND THE BEST PRE-LUBRICATED BEARING DESIGN
The Reliance pre-lubricated bearing provides *four times more operating hours without re-lubrication* than any other bearing used in motors today. And—whatever your lubrication schedule—*you just can't grease'em wrong!* To get the complete "inside story" on motor bearings, write today for Bulletin B-2201. It contains hard facts on the advantages of the Reliance pre-lubricated bearing design, with cutaway view, cross-section diagram, comparison chart, and statements by bearing manufacturers. B-1455E

RELIANCE ELECTRIC AND ENGINEERING CO.

1065 Ivanhoe Road, Cleveland 10, Ohio • Sales Representatives in Principal Cities



Here's how Foster Wheeler

WASTE HEAT BOILERS

meet industry's needs for better fuel economy in wide range of services

Exhaust gases from kilns, Diesels and other engines, furnaces and many processes contain valuable heat energy. Instead of wasting this heat by discharging the gases into the atmosphere, more and more plants are recovering it—in the form of steam—through the installation of Foster Wheeler WASTE HEAT BOILERS.

At a steel company, for example, eleven waste heat boilers serving gas engines generate 140,000 lb steam per hr at 150 psi. In another installation, exhaust gases from a 3850 hp Diesel at 510F produce 2250 lb steam per hr at 25 psi.

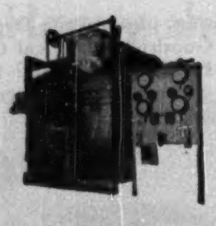
At a cement plant, three waste heat boilers operating with kilns recover 84,000 lb per hr of steam at 275 lb psig, 564F.

WASTE HEAT BOILERS BRING EXTRA SAVINGS TO THESE INDUSTRIES

Ammonia manufacture	Paper mills
Cement mills	Power stations
Chemical plants	Sewage plants
Copper smelting	Steel mills
Metal refining	Sulphuric acid plants
Oil refineries	

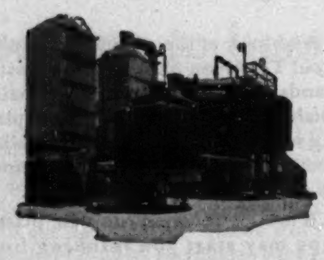
Foster Wheeler engineers welcome the opportunity to determine the fuel economies that waste heat boilers may make possible in your plant. Foster Wheeler Corporation, 165 Broadway, New York 6.

MEETING THE EXACTING NEEDS OF THE PROCESS INDUSTRIES



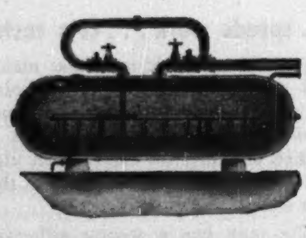
DOWTHERM HEATING SYSTEMS

For processes requiring precision control of high constant temperatures at low pressures. Inexpensive to maintain, simple to operate vaporizers and complete systems.



SULPHUR RECOVERY EQUIPMENT

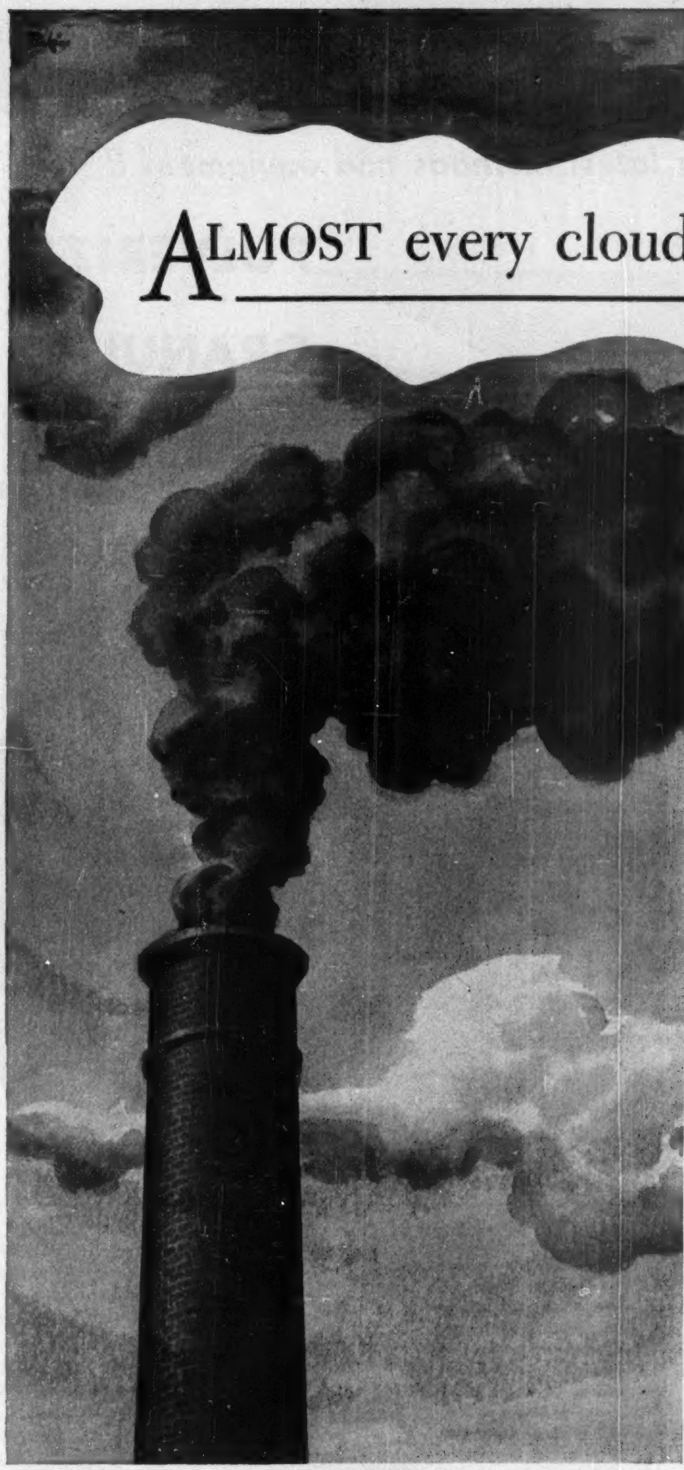
Converts H_2S and CS_2 from waste gases into income-producing gases.

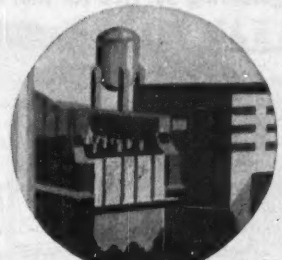


STEAM ACCUMULATORS

Automatically store steam to meet peak demands of process plants. Permit operation of boilers at constant, most economical rate.

FOSTER WHEELER



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for latest methods and equipment if you:
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CLASSIFY BY AIR
SEPARATE BY SIFTING
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The pioneer ball bearing roller mill. High capacity, with fine, even, grainy product.
AIR CLASSIFIER
Absolute air classification—no moving parts. Classifies and separates fractions ranging from 1 to 100 microns.
GYRATOR SIFTER
Separates fibers, shreds, coarse particles from all types of pulverized materials. Non clogging.
Consult SCHUTZ-O'NEILL
Engineering Service for Mill Plans
Illustrated here are two from a large variety of Mill Plans, suggesting efficient operating set-ups for any material or plant layout. If you will advise us of your requirements, Schutz-O'Neill Engineers will recommend a suitable mill plan and equipment for your own use.
MILL PLAN 45—Mill, Horizontal Tubular Dust Collector, Elevator, Gyrator Sifter.
MILL PLAN 30—Mill, Cyclone Collector, Tubular Dust Collector.
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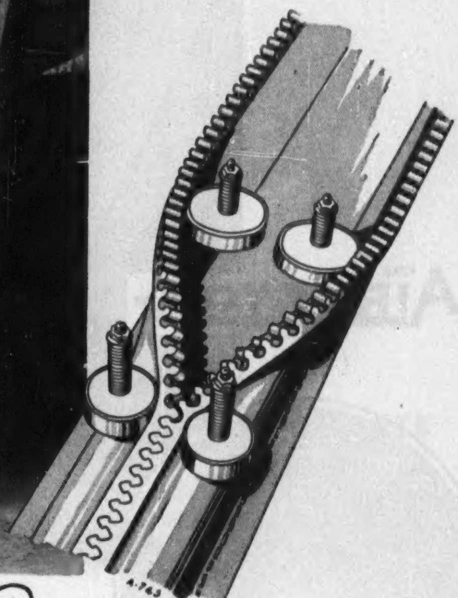
PATHFINDER CHEMICAL COMPANY

Three 4-inch S-A Zipper Conveyor-Elevators move 1500 pounds of granular resin from dryer units to storage units. The resin moves in a totally enclosed belt. From the driers the Conveyor-Elevators move horizontally before rising 26 feet vertically, then move horizontally again at right angles to the lower run.



this S-A CONVEYING System uses Zippers

to keep GRANULAR RESIN CLEAN

Eliminating all possibility of contamination, from both within and without the conveyor, is a No. 1 requirement in handling this pure granular resin. S-A engineers solved the problem with S-A Zipper Conveyor-Elevators that handle 1500 pounds per hour—in totally enclosed rubber tubes that prevent deposit of metallic particles due to abrasion. Faced with *any* bulk materials handling need—no matter how specialized or unusual—S-A engineers draw upon a vast store of experience and a complete line that includes every kind of bulk handling equipment. If you have a problem, why not put it up to them? In all probability they'll solve it for you and cut your handling costs besides. Write for a free survey.

REDLER Conveyor-Elevators
ZIPPER Conveyor-Elevators
Vibrating Conveyors
Belt Conveyors
Screw Conveyors
Bucket Elevators
Pan Conveyors and Feeders
Circular Bin Dischargers
Centrifugal Loaders and Pilers
TELLEVEL Bin Level Controls
Ship Loaders and Unloaders
Storage and Reclaiming Systems
Box Car Loaders and Unloaders
Bin Gates, All Types
SEALMASTER Ball Bearing Units

Write for Bulletins on any of the above.

STEPHENS-ADAMSON MFG. CO.

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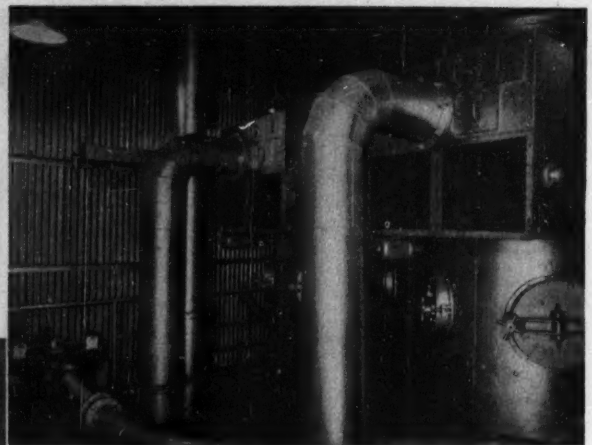
DESIGNERS AND MANUFACTURERS OF ALL TYPES OF BULK MATERIALS HANDLING EQUIPMENT

controlled windstorm works for

WESTERN ELECTRIC



Four compartment, continuous automatic Airveyor filters

The AIRVEYOR®

Storage bins served by the Airveyor

A light breeze sends leaves skipping down the street, a strong wind shifts thousands of tons of sand in the Sahara. Fuller Airveyors in the Western Electric Co. Indianapolis, Indiana, Plant, use the tremendous carrying power of moving air, control it, direct it . . . shift thousands of tons of granular molding compounds from trucks and drums to storage . . . then from storage to processing operations.

Many other companies use Airveyors to convey such materials as these, more efficiently, economically and faster:

Alum • Borax • Clay • Cellulose acetate • Vinylite • Fuller's earth • Gypsum • Lime • Magnesium • Pulverized Phosphate Rock • Salt • Soda Ash • Barley • Bran • Coffee • Corn • Flour • Malt • Oats • Rye • Starch • Sugar • Wheat

Considerable savings result when Airveyors are used to convey pulverized or granular materials over long or short distances, or through a single line or multiple distributing system, in quantities from a few tons to as much as 300 tons an hour. Material losses and dust nuisances are eliminated; manpower is reduced; maintenance is a minor matter.

A Fuller engineer will be glad to discuss your conveying problems with you, show you how the Airveyor can save costs, streamline your operations.

Fuller

DRY MATERIAL CONVEYING SYSTEMS AND COOLERS • COMPRESSORS AND VACUUM PUMPS • FEEDERS AND ASSOCIATED EQUIPMENT

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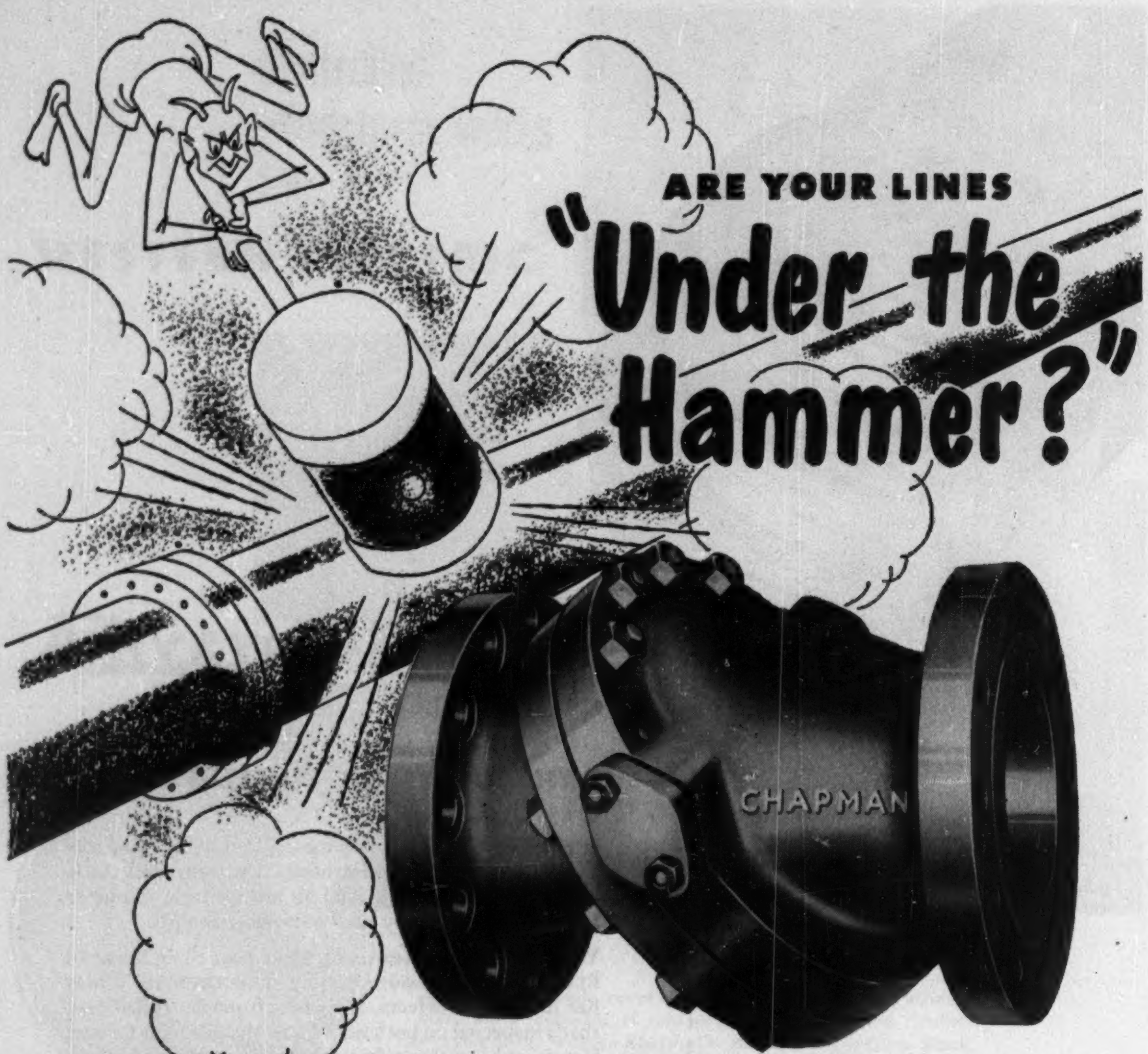


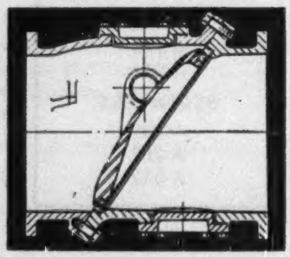
... here's how to get them out from under with

CHAPMAN *Tilting Disc* CHECK VALVES

Loosened pipe-joints are caused by hammering. And hammering is caused by valve-slam. But when a valve can't slam under usual piping arrangements . . . then you're free from the danger of line damage.

And this is all because of the Chapman Tilting Disc, with specially designed airfoil section that means light weight, and perfect balance in the open position, so it is easily held open in the flow . . . and then dropped quietly to a *cushioned closing* that does not even jar the line.

That's why certified tests from the country's top engineering schools and actual installations prove that Chapman Tilting Disc Check Valves reduce head-loss over regular swing-type checks. Check these tests for yourself . . . write for Catalog No. 30.



Cross-section of the Chapman Tilting-Disc Check Valve. A feature of the design is that the disc seat lifts away from the body seat when opening, and drops into contact when closing, with no sliding or wearing of the seats.

The Chapman Valve Mfg. Co.

INDIAN ORCHARD, MASSACHUSETTS

TO PROTECT running gear with dependably cooled lube oil

"Install it, start it — then forget it!"

That's what Joy Manufacturing Company has to say about its Heavy-Duty WN-114 Air Compressors. To back these claims — Joy Compressors are equipped for constant, dependable service 24 hours a day, year in and year out.

Centered in the force-feed lubrication system in each of these compressors is a compact Ross Type BCF Exchanger. Main bearings, crank pins, connecting rods, cross head pins and other close tolerance parts never go wanting for properly cooled lube oil. They depend on temperature safety — *and they get it!*

Rugged dependability has not only made Ross Exchangers standard components on most makes of compressors as lube oil coolers — but as intercoolers and aftercoolers as well. In fact, Ross Exchangers are used throughout industry to control temperatures in engines, speed increasers, turbines, torque converters and numerous types of hydraulic machinery.

Sound reasons underscoring this acceptance:

They're pre-engineered, fully standardized and constructed of enduring copper and copper alloy. More information on Ross Type BCF Exchangers is in Bulletin 1.1K5. Write for your copy!

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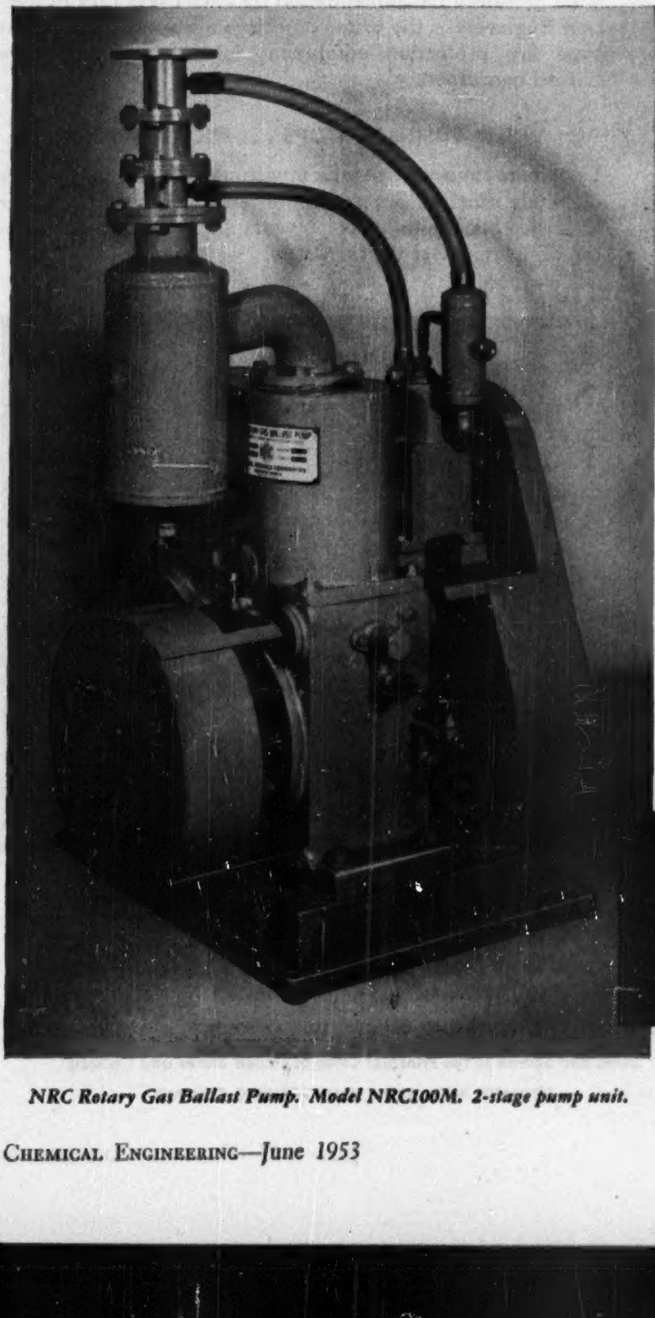
NEW HIGH VACUUM ROTARY PUMP

...Ends Water Vapor Trouble
...Maintains Fast Pump Down Time



NRC Rotary Gas Ballast Pump. Model NRC100M. 2-stage pump unit.

- **Eliminates oil reclaiming units**
- **Provides greater capacity under 1 mm Hg**
- **Requires up to 80% less oil charge**
- **Capacities from 1¼ cfm to 400 cfm**
- **Pressures down to 10^{-4} mm Hg**

For the first time, a high vacuum rotary pump that can pump condensable vapors is available to U. S. A. industry.

In the new NRC Rotary Gas Ballast Pump water vapor is *prevented* from condensing and contaminating the oil . . . so, unlike other type pumps, fast pump down time is *maintained.*

There is a full line of NRC pumps — vane, piston-type and 2-stage.

Send today for the new bulletin that gives a full explanation of the Gas Ballast principle and complete data on the construction and operation of the NRC Rotary Gas Ballast Pump

NRC

National Research Corporation
EQUIPMENT DIVISION

70-A Memorial Drive, Cambridge, Massachusetts

A man with a hate

● There's no halfway feeling about fire and its resulting destruction with an expert fire protection engineer ... he actually hates to see a little fire roar into a raging inferno and create a sizeable loss.

This personal sense of responsibility is inherent with C-O-TWO Fire Protection Engineers ... a definite plus in your behalf. Whether its fire detecting or fire extinguishing ... portables or built-in systems ... C-O-TWO means top quality backed by experienced engineering that results in operating superiority for you at all times.

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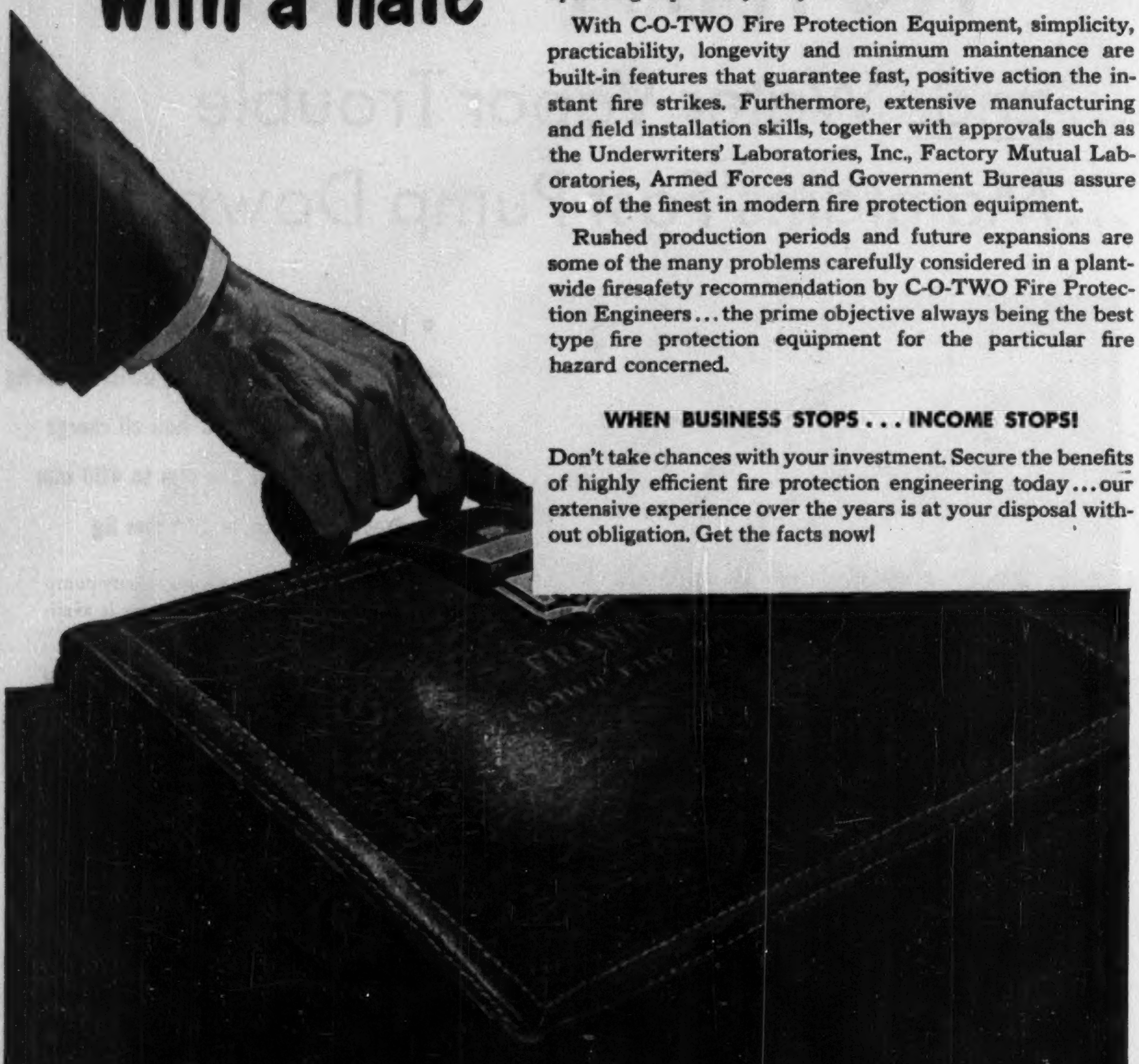
Rushed production periods and future expansions are some of the many problems carefully considered in a plant-wide firesafety recommendation by C-O-TWO Fire Protection Engineers ... the prime objective always being the best type fire protection equipment for the particular fire hazard concerned.

WHEN BUSINESS STOPS . . . INCOME STOPS!

Don't take chances with your investment. Secure the benefits of highly efficient fire protection engineering today ... our extensive experience over the years is at your disposal without obligation. Get the facts now!



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Squeez-Grip Carbon Dioxide Type Fire Extinguishers
Dry Chemical Type Fire Extinguishers
Built-In High Pressure and Low Pressure Carbon Dioxide Type Fire Extinguishing Systems
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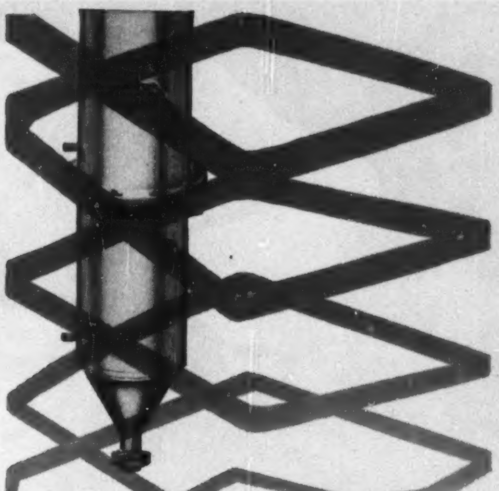

The Turba-Film Evaporator

Hard-to-process, unstable chemicals no longer present a constant problem for evaporating, heat treatment, stripping, cooling by evaporation, deodorizing or distilling. With the patented Rodney Hunt Turba-Film Evaporator (Luwa Process, Switzerland) liquids, slurries and gases . . . especially heat-sensitive and heavy viscous materials . . . are continuously processed in a single, few-second pass. The Turba-

Problem*Chemicals Now Continuously Processed

Film Evaporator works on the thin-film principle of evaporation, but its advanced design creates *turbulence* in the film—overcomes the disadvantages found in the ordinary falling thin-film systems. There's no localized overheating; foaming or frothing difficulties are overcome. And where only vapors are wanted, tests show distillation up to 99%.

The Turba-Film Evaporator retains color, potency, odor, nutritional and other valuable "original" properties. Maintains high "U" values . . . 100 to 500. No hydrostatic head. No vapor binding. The Turba-Film Evaporator is compact, easy to clean, easy to maintain, easy to change over from one product to another. Prove its revolutionary advantages yourself . . . in our plant or yours. Mail this coupon for full details.

*Solvents . . . Latices . . . Pharmaceutical "Mycins" . . . Juice Concentrates . . . etc.

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PROCESS EQUIPMENT DIVISION
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Please send FREE brochure giving details of Turba-Film Evaporator.
☐ **I want details on your testing program.**

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Type of Industry...............................Product...................................

CE6

Here showing "Aircomatic" welding on Aluminum shell of a 54″ o.d. x 10′ fixed tube sheet Heat Exchanger. Inset shows the completed job of one of three such units on the order.

. . . yes, let DOWNINGTOWN's experience and research in the fabrication of various grades of Carbon Steel, Stainless Steels, Nickel-Clad, Stainless-Clad, Monel-Clad, Cupro-Nickel, Aluminum, etc. be of help to you. We are equipped with the most modern facilities to handle complete jobs, within our limitations, in the correct alloys and methods of fabrication required to assure maximum operating efficiency.

DOWNINGTOWN's Heat Transfer Division is under the direction and supervision of men thoroughly trained and experienced in this field. Our Engineering Consultation is at your service to aid you in preparation of plans and specifications for definite jobs.

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DIVISION OF PRESSED STEEL TANK COMPANY

When you can't see for the dust...

SPECIFY KAISER ALUMINA!

If alumina dust hampers your production and adds to your costs through excessive waste—*switch to Kaiser Alumina!*

Dust is minimized with Kaiser Alumina because the grains are *accurately sized* to meet specific applications. It's available in several sizes—from fine grades to coarse grades prepared for large bulk users. This careful sizing also insures *free flow* to help speed your operations.

This "tailoring" of alumina to customers' requirements was pioneered by Kaiser Chemicals. Such aggressive research on customer problems is another reason why Kaiser Chemicals has become a major supplier of calcined and hydrated aluminas, serving more than 80% of the nation's users.

Whether you manufacture abrasives, glass, ceramics, refractories, catalysts, or chemicals for water treatment, Kaiser Chemicals will give your order *immediate, individual attention.* Contact principal sales offices: Chemical Division, Kaiser Aluminum & Chemical Sales, Inc., Oakland 12, California; First National Tower, Akron 8, Ohio.

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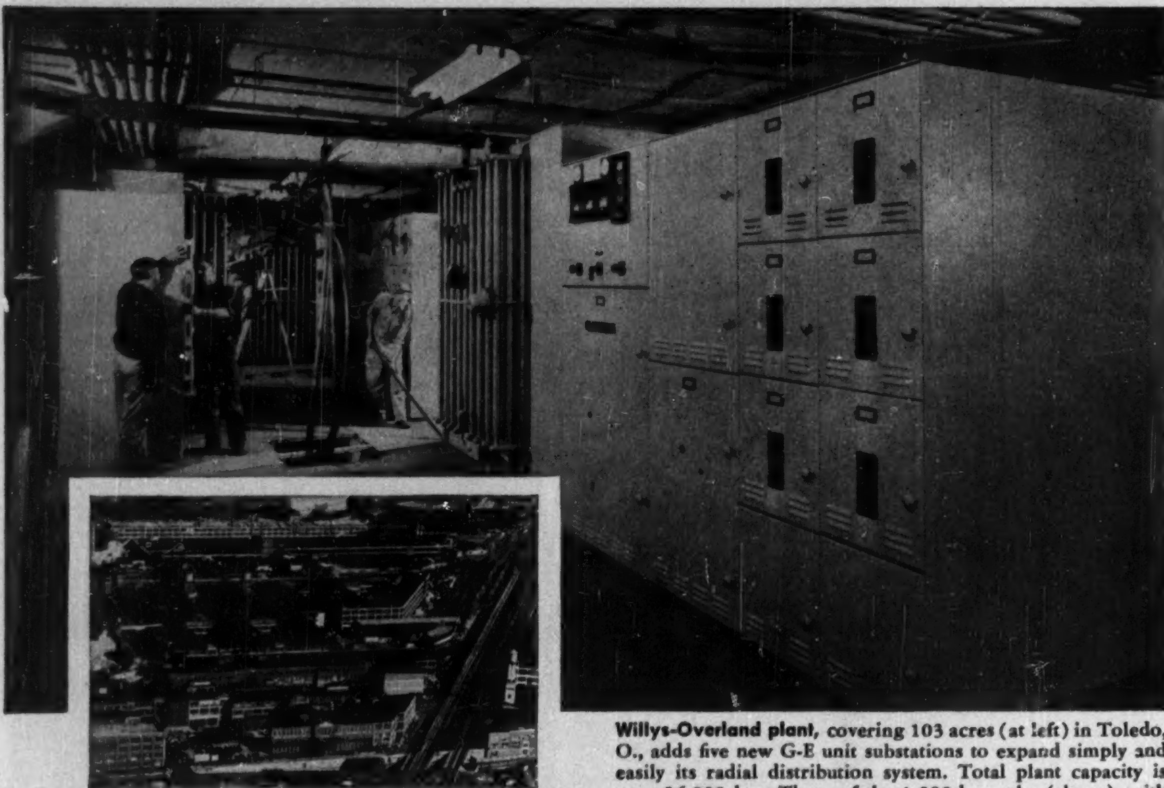
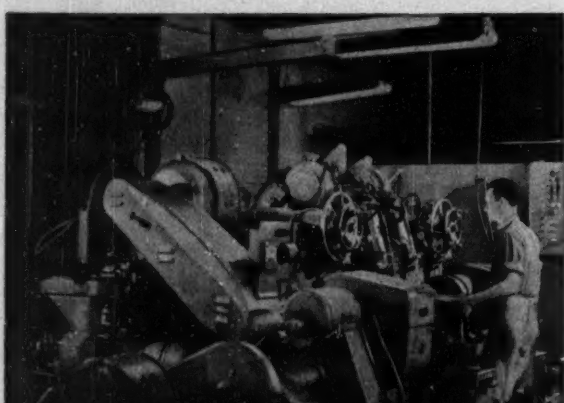
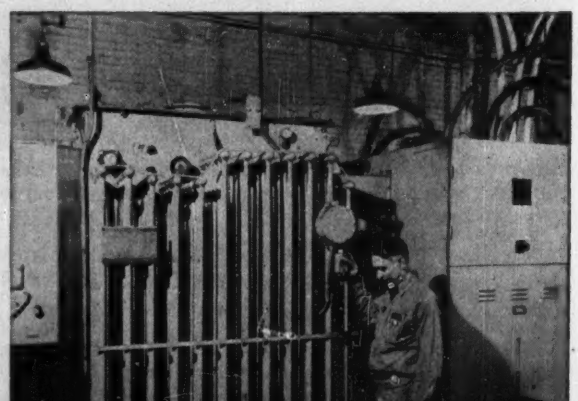
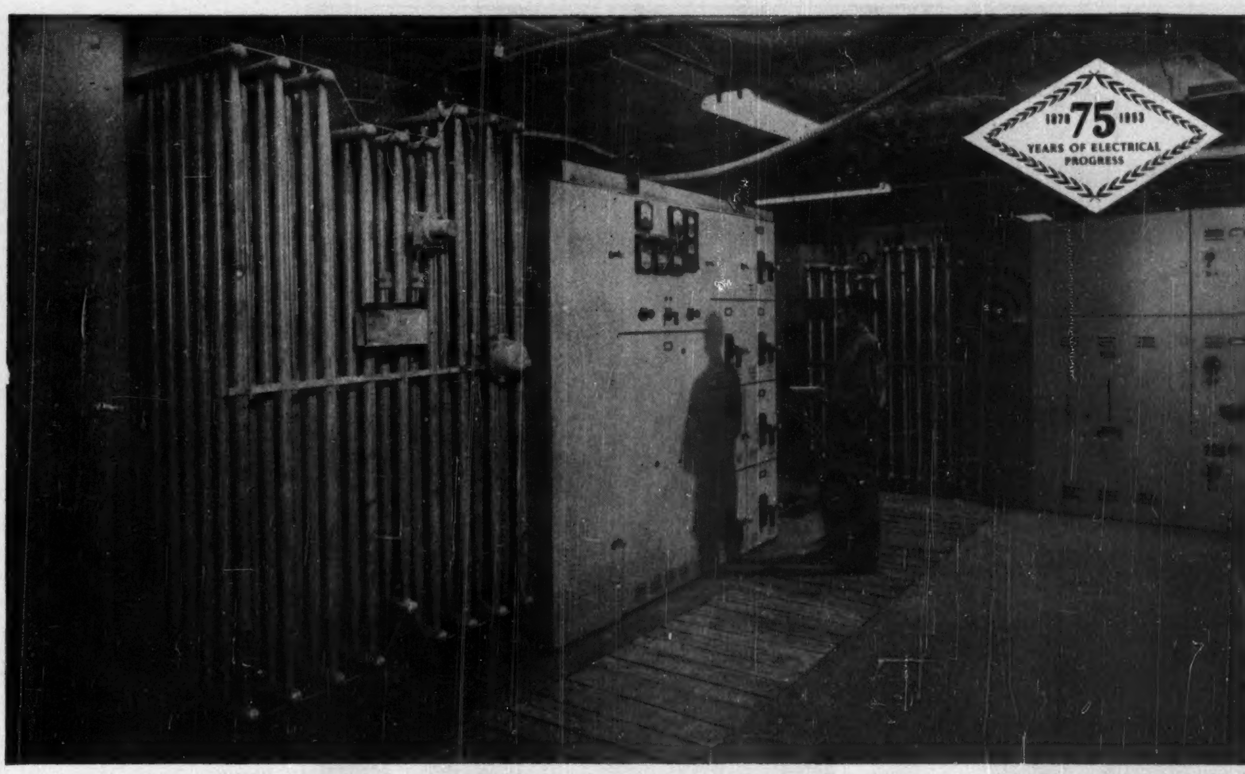
calcined and hydrated aluminas

Alumina • Basic Refractory Bricks and Ramming Materials • Dolomite • Magnesia • Magnesite • Periclase









New load-center units, are added to system which has operated for 13 years without power failure. Addition of new substations, like the two new 1,500-kva units above, does not alter over-all system, provides high degree of flexibility to handle shifts in plant loads. Unit subs, used as building blocks, can be placed wherever needed.

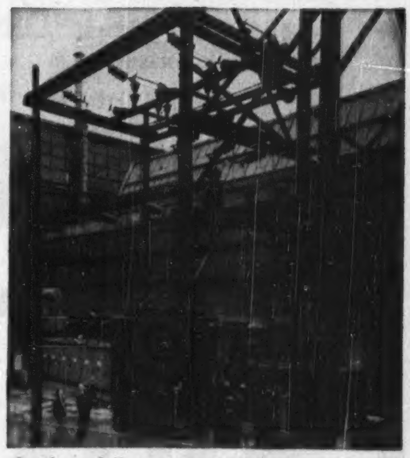
systems: Never a power failure!

G-E radial distribution system, installed in 1939, easily expanded to 26,000 KVA for increased plant loads

Flexibility in reliable power distribution for stepped-up production of Jeeps . . . quick, easy power expansion at little expense . . . low-cost maintenance with maximum safety. The Willys-Overland Company in Toledo found these advantages of its plant's radial distribution system multiplied when five new G-E 1,500-kva load-center substations were added recently for greater plant capacity.

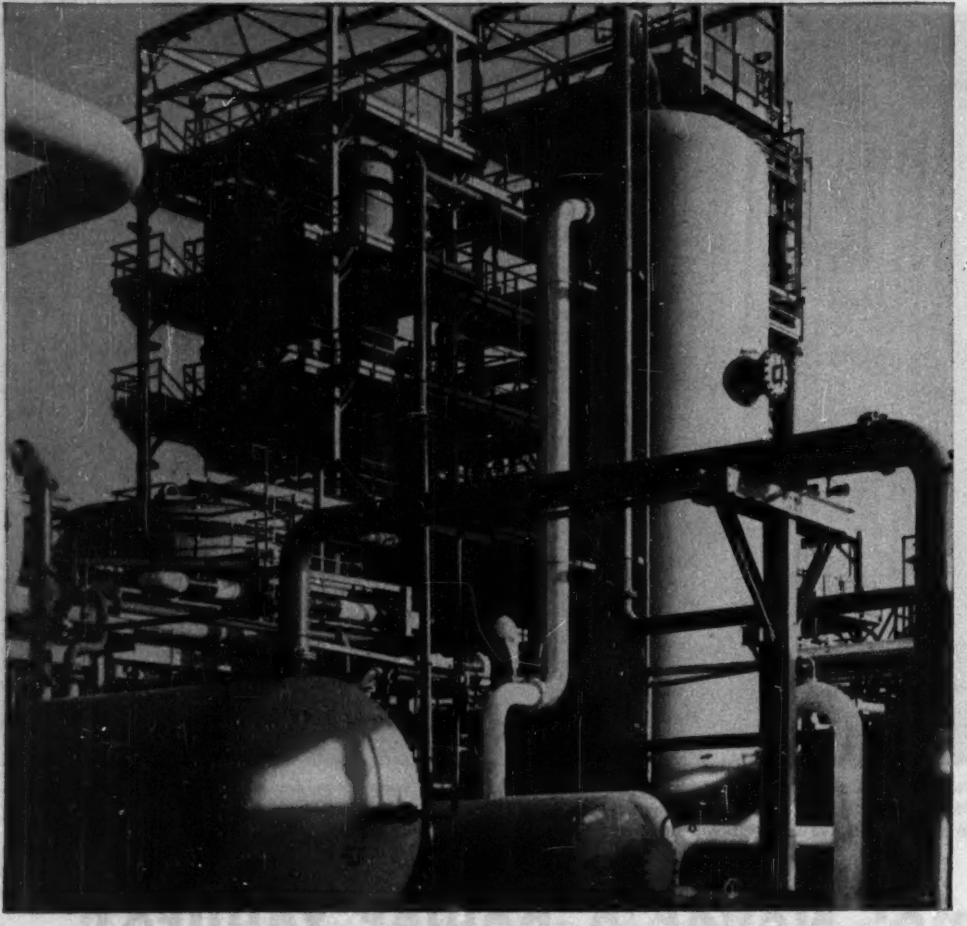
During the past 13 years of trouble-free operation, engineers have had first-hand experience with the low cost, simplicity, and reliability of the radial system. A G-E outdoor unit substation furnishes plant power, steps down utility voltage to a usable 4,160 volts. Eighteen unit substations handle load requirements in more than two-score buildings on the 103-acre tract.

This installation is just one example of the way G-E engineering helps industry meet demands for more power. For further information, contact your G-E sales representative, or write for GEA-3592. General Electric Company, Schenectady 5, New York. 881-1



Outdoor G-E master unit substation, plus an indoor G-E station, furnishes power for 90 per cent of Willys-Overland capacity.

GENERAL ELECTRIC



A complete line of dependable products for Industry

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PARATONE
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Methyl Ethyl Ketone
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PETROHOL 99
Secondary Butyl Alcohol
Secondary Butyl Acetate
Isopropyl Acetate
Acetone
Methyl Ethyl Ketone
Ethyl Ether
Isopropyl Ether
Dicyclopentadiene
Naphthenic Acids
Iso-Octyl Alcohol
Decyl Alcohol

CHEMICAL
PETROHOL 91
PETROHOL 95
PETROHOL 99
Iso-Octyl Alcohol
Decyl Alcohol
Tridecyl Alcohol
Dicyclopentadiene
Isoprene
Butadiene
Ethyl Ether
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In the Chemical Industry

where performance counts you can count on Enjay for...

Uniform, High Quality

PETROHOLS

(ISOPROPYL ALCOHOL)

ENJAY

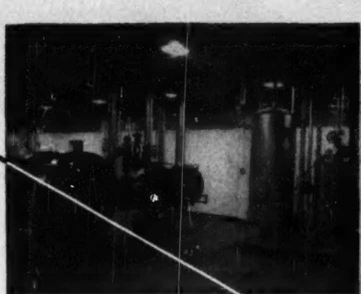
A pioneer and leading marketer of isopropyl alcohols, the Enjay Company offers a complete line of Enjay *Petrohols.* More and more manufacturers are counting on Enjay for their supply of *Petrohols,* methyl ethyl ketone and other Enjay solvents widely used in the surface coating and chemical industries.

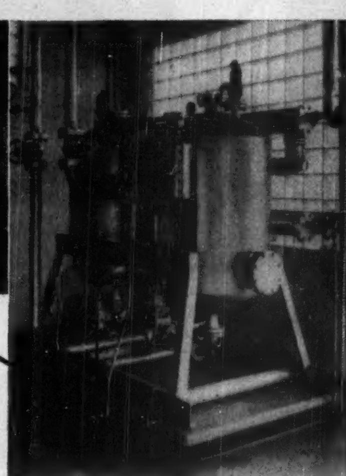
The Enjay Company has long been recognized as a leader in the development and marketing of high-quality products for the oil, surface coating and chemical industries. Backed by greatly expanded plant and distribution facilities, the Enjay Company is supplying a constantly growing list of chemical products to many different industries.

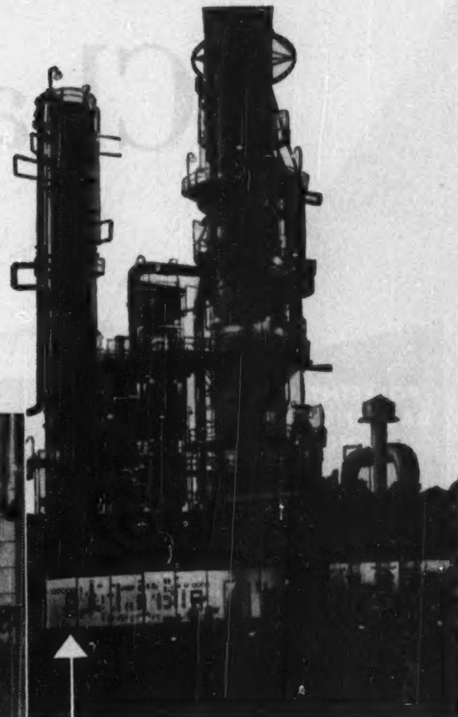
BE SURE TO CALL ON ENJAY FOR YOUR CHEMICAL NEEDS

ENJAY COMPANY, INC.
15 West 51st Street, New York 19, N. Y.

Lectrodryer* feeds the nerve center DRY AIR only!







Type BY-5 Lectrodryer provides continuous flow of dried air to panels in control room, protecting vital control instruments and lines against moisture. →

Automatically controlled McMurrey Refinery near Tyler, Texas. One operator in the control room can control and watch over its entire operation.

2300 instruments . . . 900 controllers and valves depend on DRY air to put this giant through its paces automatically. If unwanted moisture were to creep into instrument air at the nerve center, the refinery could be thrown haywire! An instrument line freeze-up, rust, scale or sludge clogging tiny ports could cause a long shutdown.

For 24 hours a day a Lectrodryer feeds the nerve center a constant stream of air dried to a dewpoint of -50° F. Moisture doesn't have a chance!

Lectrodryers catch the moisture which separators and filters let by. Throughout the chemical and petroleum industries they dry air, gases and organic liquids . . . automatically, economically, continuously. For extreme dryness there are Lectrodryers drying down to 3 to 4 parts per million or less.

Whatever the drying need, there's probably a Lectrodryer already built to handle it. Our engineers will help you lay out your system and select proper equipment. Write: Pittsburgh Lectrodryer Corporation, 303 32nd Street, Pittsburgh 30, Pa.

In England: Birlec, Limited, Tyburn Road, Erdington, Birmingham.
In France: Stein et Roubaix, 24 Rue Erlanger, Paris XVI.
In Belgium: S. A. Belge Stein et Roubaix, 320 Rue du Moulin, Bressoux-Liege.

LECTRODRYERS DRY WITH ACTIVATED ALUMINAS

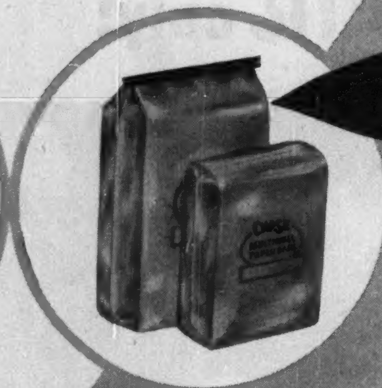
LECTRODRYER

*REGISTERED TRADEMARK U.S. PAT. OFF.

Chase Bag

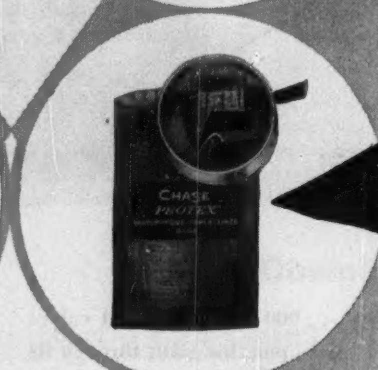
makes

POLYETHYLENE BAG AND DRUM LINERS



MULTIWALL BAGS

SHARKRAFT BAGS



PROTEX WATERPROOF PAPER LINED BAGS

for the Chemical Industry

Complete protection of your product plus attractive appearance . . . the result of over 100 years experience in designing and making bags.

SINCE 1847

CHASE BAG COMPANY

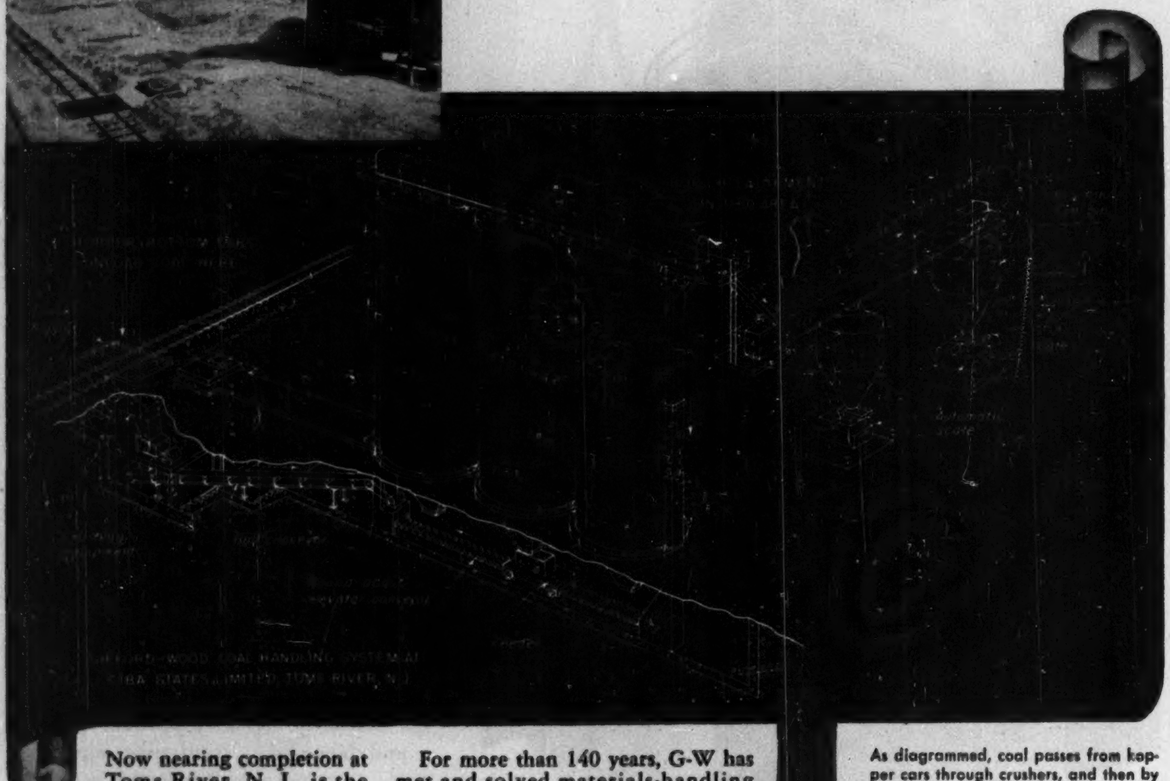
GENERAL SALES OFFICES 309 W. JACKSON BOULEVARD
CHICAGO 6, ILLINOIS

30 BRANCHES AND SALES OFFICES STRATEGICALLY LOCATED

▲ Enclosed flight conveyor and 60-ton coal bin.
Under-track hopper and coal storage silos. ▼

ANOTHER G-W AUTOMATIC COAL HANDLING SYSTEM...

this time for Ciba States Ltd.



Now nearing completion at Toms River, N. J., is the world's most modern vat-color producing plant—and helping insure maximum power development with top economy will be the most efficient coal handling system, by Gifford-Wood. The system was designed and built by G-W engineers for Ciba States Limited, and includes unloading, storage, and feeding facilities.

For more than 140 years, G-W has met and solved materials-handling problems. This experience, coupled with planned application of the most modern equipment, is at your disposal. This project is only one example of complete design, construction, and erection under one responsibility

For details on this, or other Gifford-Wood coal handling installations, please write for Bulletin No. 300.

As diagrammed, coal passes from hopper cars through crushers, and then by means of belt and bucket conveyors, to silo storage. Transfer of coal from storage silos is by gravity feed into a movable car from which the bucket elevator lifts it, by-passing the storage silos, to an enclosed flight conveyor discharging into bins, which feed through coal scales to pulverizers.

GIFFORD-WOOD CO.

Since 1814
Hudson, New York

New York 17
430 Lexington Avenue

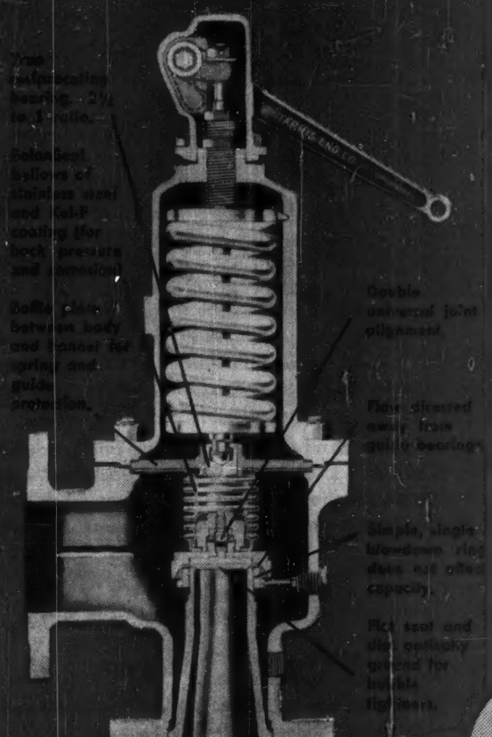
St. Louis 1
Railway Exchange Building

Chicago 6
565 West Washington Street

®8756

When You Think of Materials Handling—Think of Gifford-Wood

for economical positive* safety...



BalanSeal and FarriSeal Safety-Relief Valves

(Pat'd & Pat. Pending)

Eliminate all risk of failure—failure that might cost lives or severe damage to equipment. Rely on the only safety-relief valves guaranteed to provide positive protection, 100% of the time, under all operating conditions. Farris safety-relief valves *can't* stick, plug or corrode because the critical working parts are completely isolated from the lading fluid—and they're unaffected by back pressures in the discharge manifold. These unique valves are more economical, too, because they permit higher downstream pressure with smaller discharge piping. In many installations this saving in piping costs amounts to as much as 15 times the cost of the valves. *You* can't go wrong with BalanSeal or FarriSeal Valves because *they* can't go wrong!

Technical manual, 51B, a treatment on Back Pressure Piping and Surge characteristics and 76-page catalog is yours for the asking.

* ASME-N.B. APPROVED (Certified for Capacity)

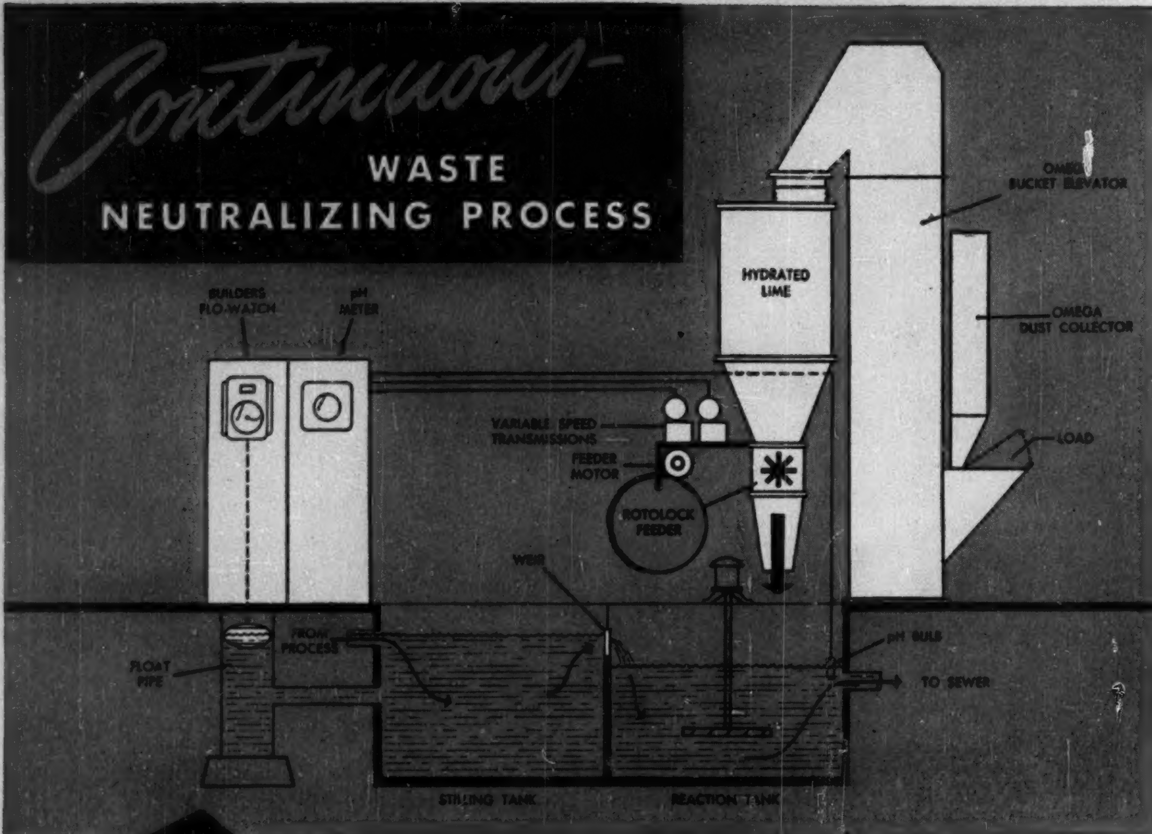
Farris

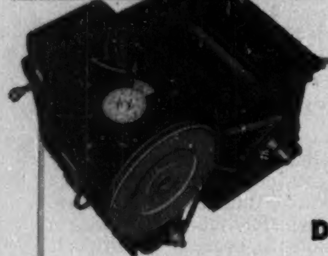
ENGINEERING CORPORATION

501 Commercial Avenue
PALISADES PARK, NEW JERSEY

Representatives in all Principal Cities

Affiliates: Farris Flexible Valve Corp. • Farris Stacon Corp. • Farris HydroTorque Corp. • Farris HydroSeal Corp.





OMEGA ROTOLOCK DOES THE JOB

Omega Rotolock — a rotating vane feeder — feeds hydrated lime into the reaction tank in response to the flow of acid waste (measured by a Builders Flo-Watch Instrument) and to the degree of neutralization (measured by a pH meter).

The Rotolock is a volumetric feeder of simple design and rugged construction, easily adapted to installations requiring proportional pacing by auxiliary meters. The Feeder, powered by a 1/4 HP motor, has a 100 to 1 feed range. Two models of Omega Rotolock Feeders are available, covering the complete range of feeds from 7.2 to 300 cu. ft. per hr.

OMEGA

B-I-F INDUSTRIES (Division of B-I-F Industries) OMEGA

Here's how Omega helped a customer's engineer solve a waste treatment problem for one of the nation's leading manufacturers of electrical and electronic equipment. This acid waste neutralizing "equipment package" comprises feeding, controlling, and metering units required for continuous, accurate operation . . . Omega bucket elevator, dust collector, storage hopper, Rotolock Feeder, and Builders Instruments and Control Panel. Performance of this "package" under actual job conditions has proven again that it pays to take advantage of Omega's engineering and manufacturing experience, when you need continuous proportioning equipment.

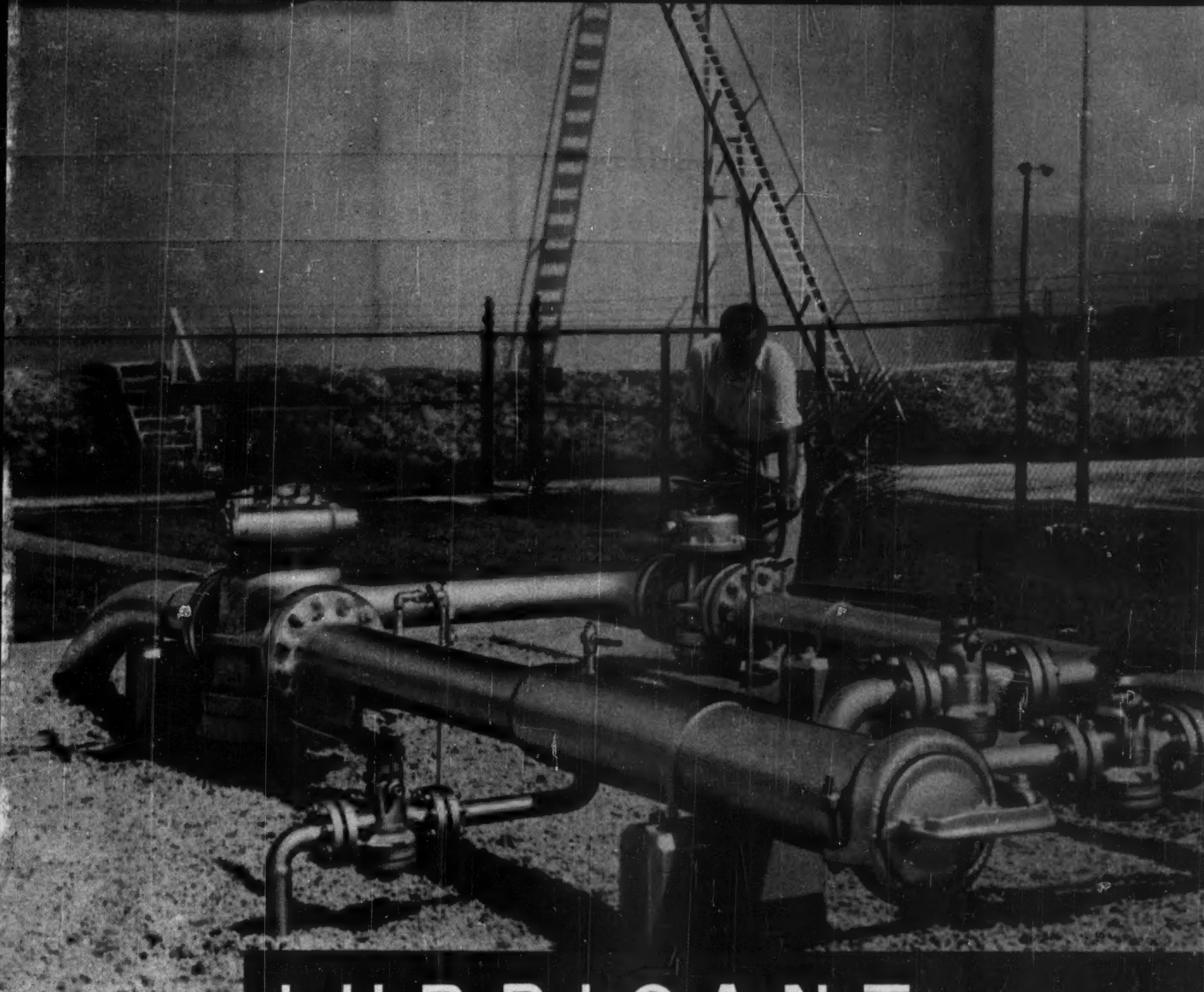
Hundreds of today's processing and production problems are being solved by Omega "packages"— for waste treatment, for proportioning two or more solids, for proportioning liquids and solids. Our engineers can help you—

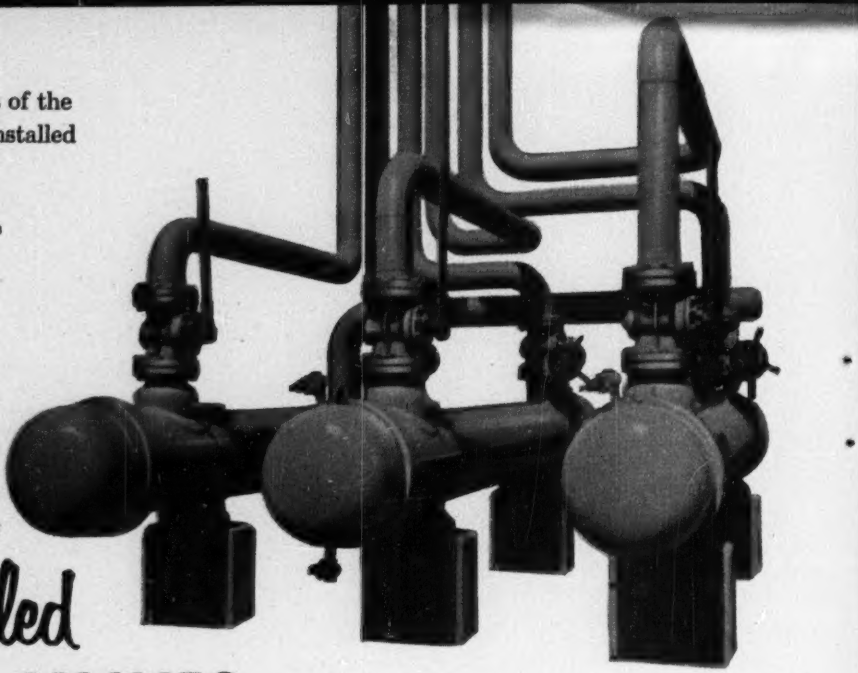
Send Coupon

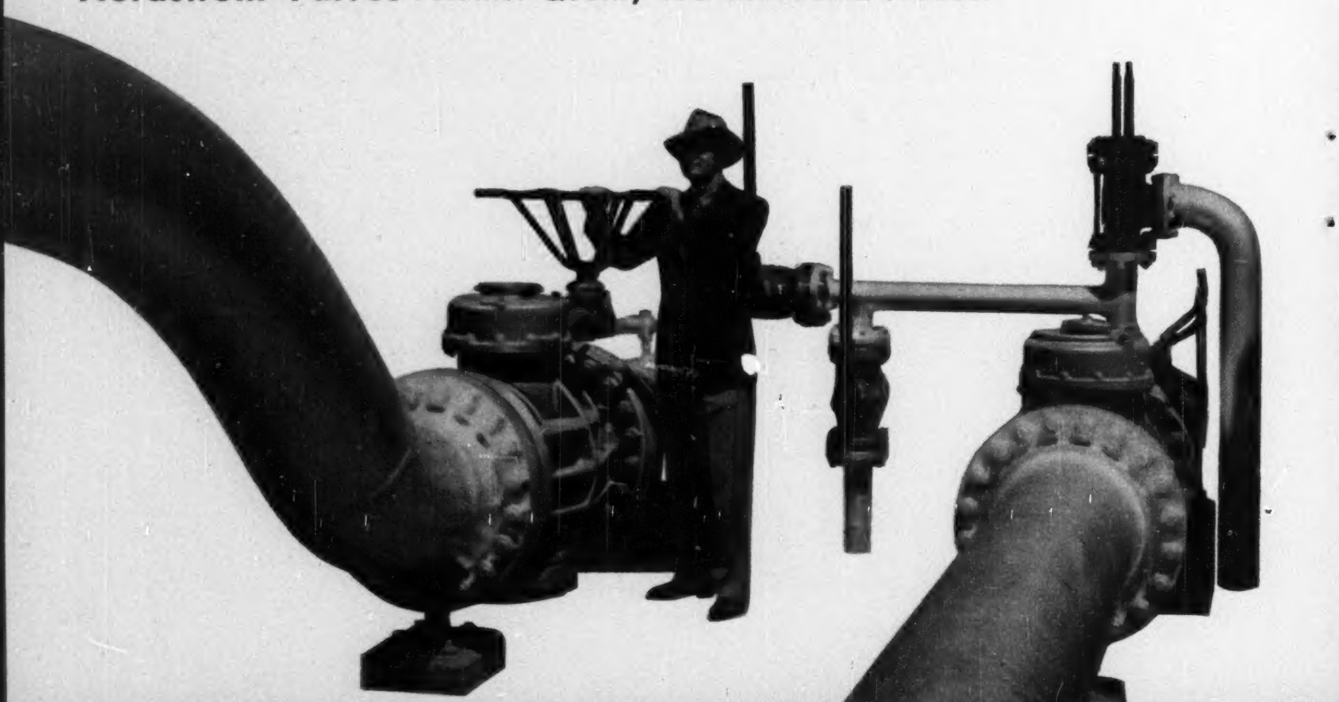
OMEGA MACHINE COMPANY
369 Harris Ave., Providence 1, R. I.

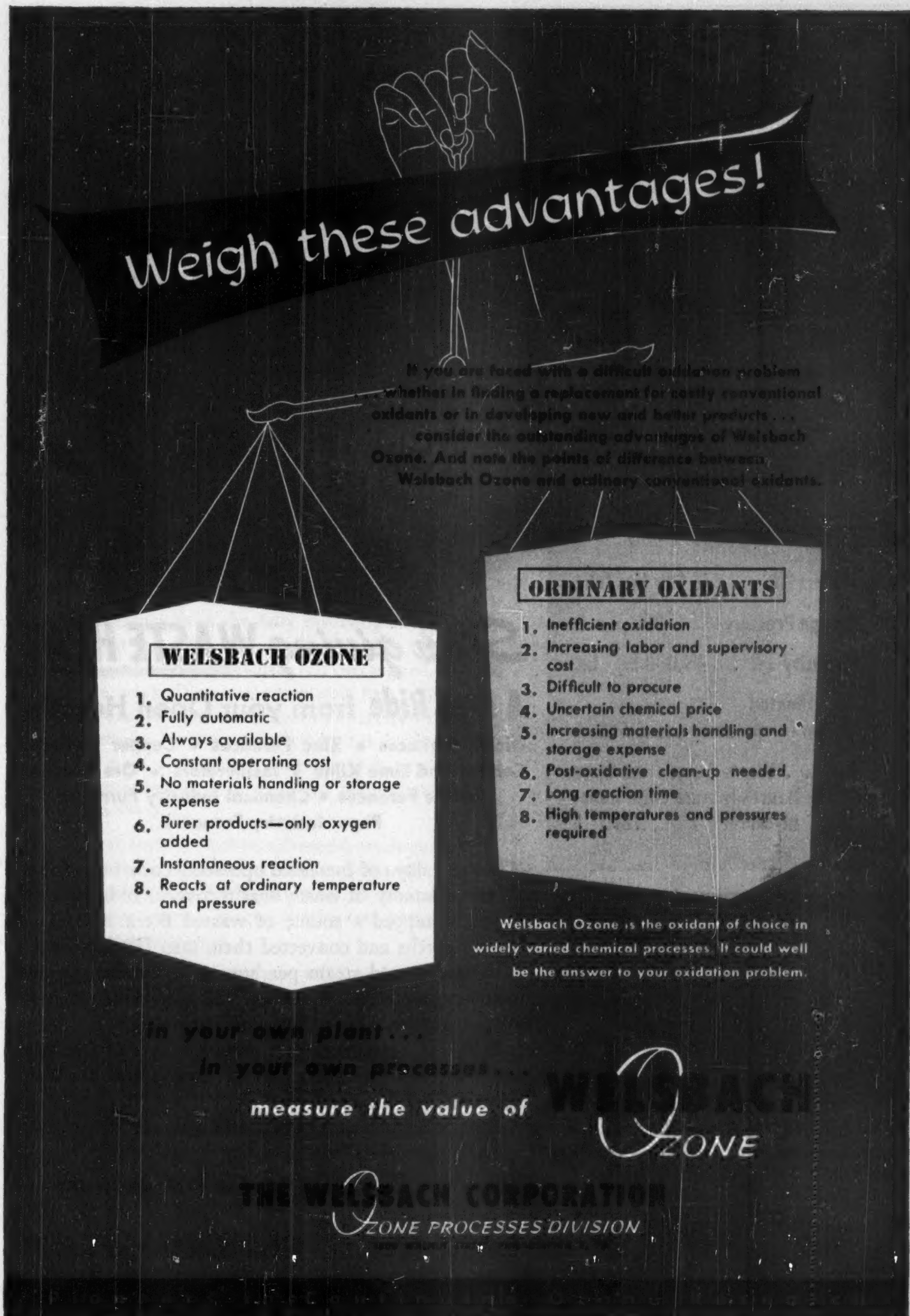
☐ Send Bulletin 45-HB describing Omega Rotolock Volumetric Feeders.
Our process problem involves:
☐ Waste treatment ☐ Proportioning solids
☐ Proportioning liquids and solids

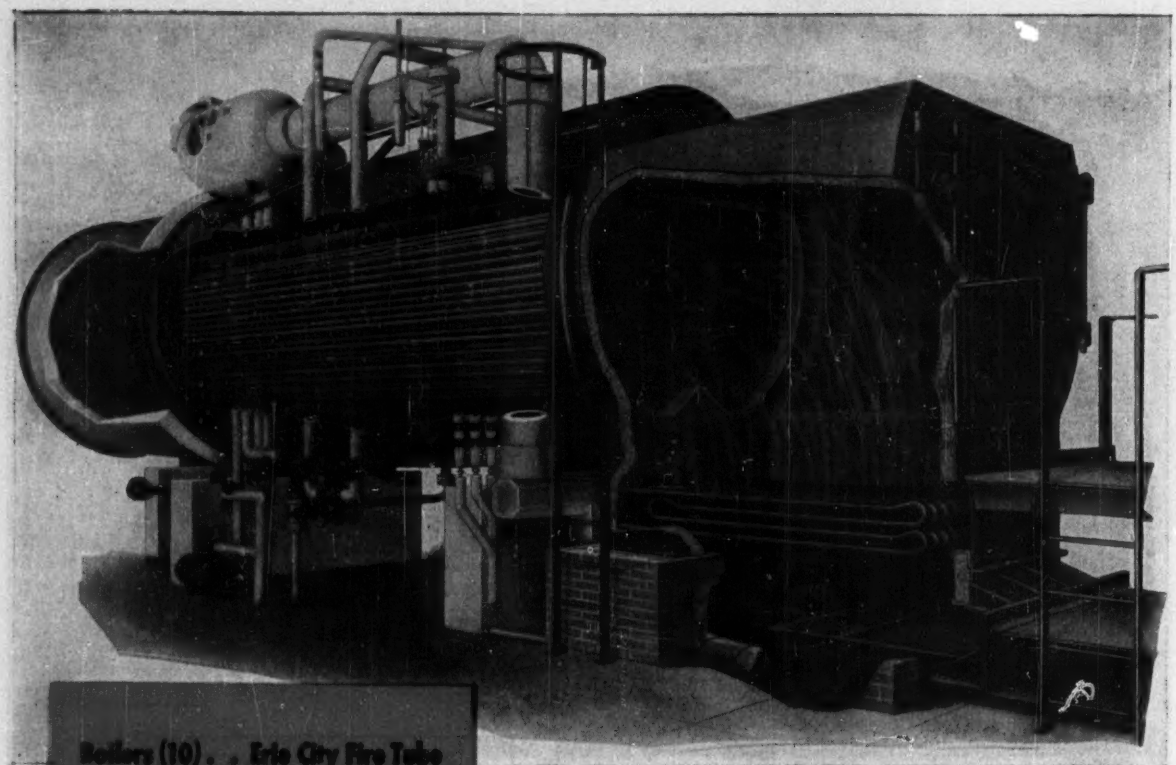
Name ____________
Company ____________
Street ____________
City ____________ State ____________



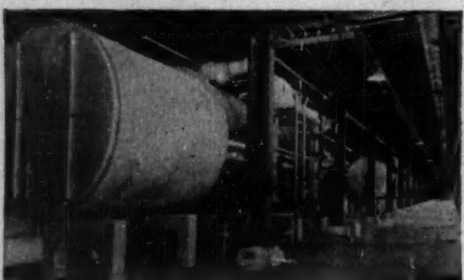





Weigh these advantages!
If you are faced with a difficult oxidation problem
. . . whether in finding a replacement for costly conventional
oxidants or in developing new and better products . . .
consider the outstanding advantages of Welsbach
Ozone. And note the points of difference between
Welsbach Ozone and ordinary conventional oxidants.
WELSBACH OZONE
1. Quantitative reaction
2. Fully automatic
3. Always available
4. Constant operating cost
5. No materials handling or storage expense
6. Purer products—only oxygen added
7. Instantaneous reaction
8. Reacts at ordinary temperature and pressure
ORDINARY OXIDANTS
1. Inefficient oxidation
2. Increasing labor and supervisory cost
3. Difficult to procure
4. Uncertain chemical price
5. Increasing materials handling and storage expense
6. Post-oxidative clean-up needed
7. Long reaction time
8. High temperatures and pressures required
Welsbach Ozone is the oxidant of choice in widely varied chemical processes. It could well be the answer to your oxidation problem.
in your own plant . . .
in your own processes . . .
measure the value of
WELSBACH
OZONE
THE WELSBACH CORPORATION
OZONE PROCESSES DIVISION



Boilers (10) . . Erie City Fire Tube
Design Pressure . . . 300 p. s. i.
Capacity . . . . 15,000 lbs/hr.
Superheated
Steam Temperature . . . 525° F
Fuel . . Waste gases from Open
Hearth furnace enter boiler
at about . . . . 1200° F



10 Erie City Fire Tube Boilers each "fired by" waste heat gases from Open Hearth Furnace

Stop giving WASTE HEAT

A Free Ride from your Open Hearths

Nickle Furnaces • Zinc Furnaces • Copper Furnaces
Cement and Lime Kilns • Incinerators • Ore Roasters
Silicate Furnaces • Chemical Industry Furnaces
Paper Industry Furnaces

IN these days of increased operating costs investigate the economy of waste heat recovery. A large steel producer tapped a source of wasted B.t.u.'s from 10 Open Hearths and converted them into 150,000 lbs. of 525° superheated steam per hour. Fuel is the big cost in steam generation; therefore "free fuel" will give you a head start in your steam generating program.

Erie City manufactures a complete line of fire tube and water tube waste heat type boilers and has wide experience in heat recovery.

Outline your waste heat conditions—our experience is yours for the asking.

You can depend on Erie City for sound engineering

ERIE CITY

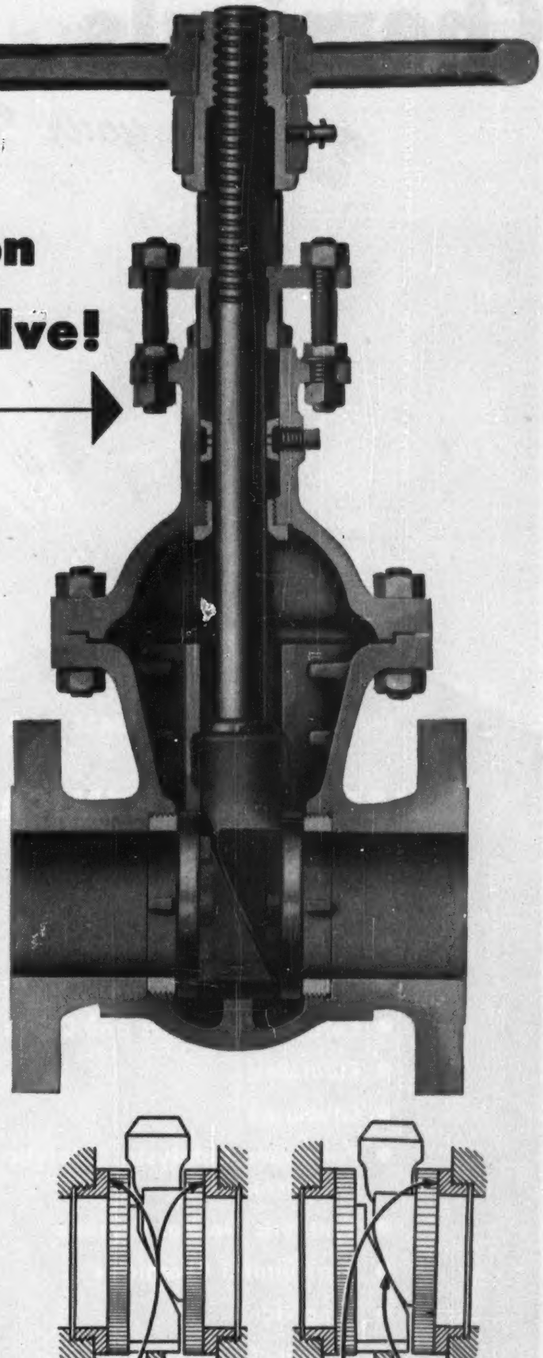
ERIE CITY IRON WORKS • *Erie, Pa.*

STEAM GENERATORS • SUPERHEATERS • ECONOMIZERS • AIR PREHEATERS
UNDERFEED AND SPREADER STOKERS • PULVERIZERS

DARLING VALVES

FOR PLUS VALUES, JOB-PROVED AGAIN AND AGAIN

Valve body distortion no problem for this valve!



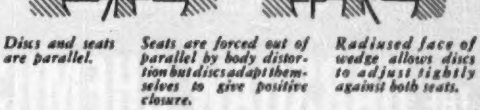
DON'T let costly valve maintenance and down-time headaches get you down! Lick these common valve troubles by installing Darling fully revolving double disc gate valves, with their unique wedging principle. They adjust *automatically* to compensate for valve body distortion—cinching tight, leak-proof closure.

The difference is in the fully revolving double disc, parallel seat principle of Darling valves. Just two plain, interchangeable no-pocket discs and two rugged wedges do all the work. Discs are completely free of pockets. Sediment and scale cannot collect to interfere with their free movement. No links or other devices are needed to hold the discs and wedges together. Any part can be quickly and inexpensively replaced without removing valve from the line.

It's easy to see why Darling valve users are money ahead because of the exceptional service made possible by the Darling design. That's why in plant after plant Darling gate valves are giving longer, trouble-free performance with minimum attention.

Darling features add up to gate valve service at its low-cost best! Send for the free Darling Valve Bulletin, today.

NOTE: Darling gate valves are made in a wide range of sizes, types and constructions, including solid and slotted taper-seat wedge types for all kinds of normal and corrosive services in pressures up to 1500 pounds.



Discs and seats are parallel. *Seats are forced out of parallel by body distortion but discs adapt themselves to give positive closure.* *Radiused face of wedge allows discs to adjust tightly against both seats.*

DARLING VALVE & MANUFACTURING CO.

Williamsport 3, Pa.

Manufactured in Canada by Sandilands Valve Manufacturing Co., Ltd. Galt 19, Ontario

STOPS FALLS!

Revolutionary New Type Safety Grating Eliminates Dangerous Walking Conditions . . . Guarantees Sure Footing.

In a recent test, shown above, a stock strip of Bustin Firm-Grip Grating was submerged in heavy chassis grease and then raised to a 15° slant. Even under those conditions, a man carrying a bulky box walked easily up and down the strip . . . maintaining perfect balance! Send for free Bustin booklet that shows industrial safety applications and specifications. Bustin Firm-Grip Grating Corp., 110 E. 130 St., New York 37, N. Y.

TEST · STUDY · CONTROL

VISCOSITY

As Simply, Quickly, Easily as Taking Temperature Readings

Brookfield

SYNCHRO-LECTRIC

VISCOMETER

Adaptable to any problem from less than one to 32,000,000 centipoises. Send for free illustrated catalog.

Just a flick of a switch, then read the Brookfield dial, and you have your viscosity determination in centipoises. The whole operation, including cleaning up, *takes only a minute or two.*

Available in a variety of models suitable for extremely accurate work with both Newtonian and non-Newtonian materials, Brookfield Viscometers are portable and plug in any A.C. outlet. *Write today.*

Address: Dept. C, Stoughton, Mass.

SLY

PIONEERS and LEADERS in INDUSTRIAL DUST CONTROL

Soy Bean Mill. Two large double file Sly Dust Filters handling soy bean meal dust.

Because of the meal dust created in processing soy beans, this company* included Sly Dust Filters, as standard equipment five years ago, in its original layout.

The Sly Filters collect 5½ tons of soy bean meal *daily*, at a value of upwards of $400. Not only is the company highly pleased with these savings but also with the resulting cleanliness of its plant. Filter maintenance has been insignificant.

In crushing, shredding, pulverizing, loading, packaging, operations—in various process industries—dust is created. If valuable, the dust can be reclaimed profitably. Even if the dust has no value its collection pays off in cleaner plants, better working conditions and reduced costs.

Expertly designed and built, Sly Dust Filters offer many advantages in greater filtering capacity, easier bag replacement, automatic control, and other features which spell low cost operation.

MAY WE TELL YOU MORE ABOUT SLY FOR YOUR PARTICULAR APPLICATION?

**Name upon request.*

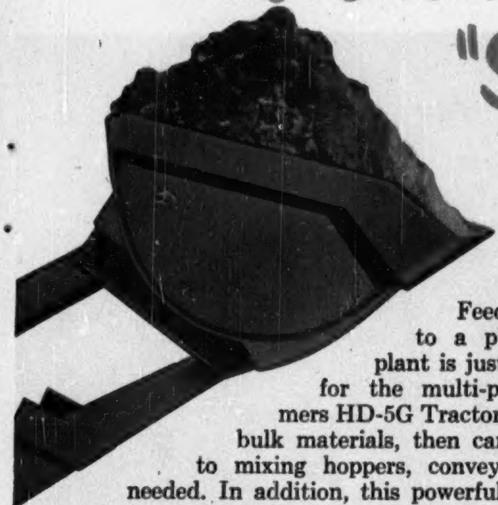
THE W. W. SLY MANUFACTURING CO.

4771 TRAIN AVENUE • CLEVELAND 2, OHIO

New York • Chicago • Philadelphia • Syracuse • Detroit • Buffalo Cincinnati • St. Louis • Minneapolis • Birmingham • Los Angeles • Toronto

FEEDING A PRODUCTION-HUNGRY PLANT WITH A

One Cubic Yard "Spoon"



Feeding raw materials to a production-hungry plant is just one of many uses for the multi-purpose Allis-Chalmers HD-5G Tractor-Shovel. It receives bulk materials, then carries them directly to mixing hoppers, conveyors or storage as needed. In addition, this powerful crawler excavates for new construction, handles coal, cleans up and loads waste . . . also clears snow and maintains yards and parking areas.

Interchangeable attachments, such as bulldozer blades, special buckets, lift fork, crane hook and trench hoe, add still further to its usefulness.

Tractor-Shovels are also available on the three larger sizes of Allis-Chalmers crawler tractors, giving a range of standard buckets from one to four cubic yards — and up to seven cubic yards for light materials.

Let your Allis-Chalmers dealer tell you more about how you can mechanize your materials-handling the efficient tractor-shovel way.

Receives Material at Plant

The HD-5G scoops a heaping load of any material at the unloading trestle, then delivers it directly to mixing hopper, conveyor, or storage area. Truck wheels, idler and support roller bearings are positively sealed against grit and moisture and require lubrication only once every 1,000 hours. This feature alone saves about 30 minutes' greasing time a day.

Builds Storage Piles—*Anywhere*

This fast-working tractor maintains large stockpiles in the open or under a protective shed. Crawler tracks provide traction and flotation to work right up on the pile, enabling it to put many more cubic yards of material into a given area. Tracks also give long life in cullet and similar material as only steel can.

Keeps Production Moving—*Fast!*

The HD-5G feeds bulk materials in exact required amounts for uniform mixture — a full cubic yard at a scoop. In handling light materials, a two cubic yard bucket doubles output. Special fast reverse greatly speeds operation on short runs. This flexible tractor starts boosting production as soon as it's put on the job . . . no waiting for costly installations or changes in plant layout when you mechanize materials handling the Allis-Chalmers tractor-shovel way.

ALLIS-CHALMERS
TRACTOR DIVISION — MILWAUKEE 1, U.S.A.

For Acid Hose Value

Whether your problem is conductance of acids and chemicals under pressure, syphoning or suction or controlled flow . . . Hewitt Monarch Acid Hose is designed to give longer life at a minimum cost.

Here's proof: "Monarch® Acid Hose, handling bright nickel solution, the basic acid of which is Sulphuric Acid (pH2.5-3.0) has held up for five years." . . . "Monarch 2" 4-ply Acid Hose, in service approximately $2\frac{1}{2}$ years has handled over 36 million gallons of Chlorate." . . . "Monarch Acid Hose, after $4\frac{1}{2}$ years and handling over 50 million gallons of chlorine, still in service."

ENGINEERING DATA

TUBE: Pure gum rubber specially compounded to resist most acids and alkalies up to 50% concentration at temperatures up to 150°F . . . safely handles many acids at any concentrations.

REINFORCEMENT: Acid Conducting Hose—multiple plies of high-tensile cotton duck with insulating cushion of rubber between plies for increased flexibility.

ACID PINCH-VALVE HOSE—two separate reinforcing walls of high-tensile cotton duck insulated from each other by a thick layer of pure gum rubber, provides maximum flexibility, assures greatest service life by eliminating crushing of duck by pinch bars when controlling flow.

ACID SUCTION HOSE—a helix of round spring wire between multiple plies of high-tensile duck provides resistance to suction forces . . . flexible, easy to handle.

COVER: Pure gum rubber designed to resist acids, alkalies and chemicals. Tough, to resist abrasion and cutting.

SIZES: All types available in $\frac{3}{4}$" to 12" I.D. and in tube thickness $\frac{1}{8}$", 3/16" and $\frac{1}{4}$".

√

CHECK FOR INFORMATION ABOUT THESE JOB-TESTED PRODUCTS FOR YOUR OPERATION

CONVEYORS:
- ☐ —Belt
- ☐ —Sectional
- ☐ —Vibrating

BELTING:
- *☐ —Elevator
- *☐ —General Conveyor
- *☐ —Hot Materials
- *☐ —Rayon
- ☐ —Woven Wire

- ☐ BUCKET ELEVATORS
- ☐ IDLERS

SCREEN CLOTH:
- ☐ —Electrically Heated
- ☐ —General

VIBRATING SCREENS:
- ☐ —Dewaterizers
- ☐ —General
- ☐ —Hydrex®
- ☐ —Slip Lawn

HOSE:
- *☐ —Acid
- *☐ —Air
- *☐ —Fire
- *☐ —Flexible Rubber Pipe
- *☐ —Pinch-Valve
- *☐ —Servall®
- *☐ —Steam
- *☐ —Twin-Weld®
- *☐ —Water

- ☐ MECHANICAL FEEDERS
- ☐ STACKERS
- ☐ CAR SHAKEOUTS
- ☐ TRIPPERS
- *☐ MOLDED RUBBER GOODS
- ☐ DESIGN AND CONSTRUCTION OF COMPLETE MATERIALS HANDLING SYSTEMS

*For immediate information about these industrial rubber products, call your Hewitt Rubber Distributor (See "Rubber Products" Classified Phone Book.)

Hewitt-Robins Incorporated
666 Glenbrook Road
Stamford, Connecticut

NAME ______________________

TITLE & COMPANY ______________________

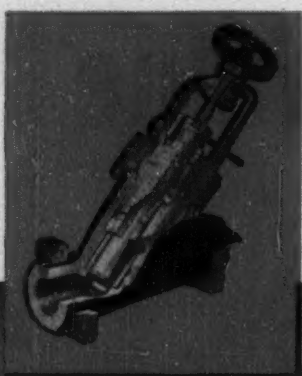
STREET ADDRESS ______________________

CITY ________ PO ZONE ________ STATE ________

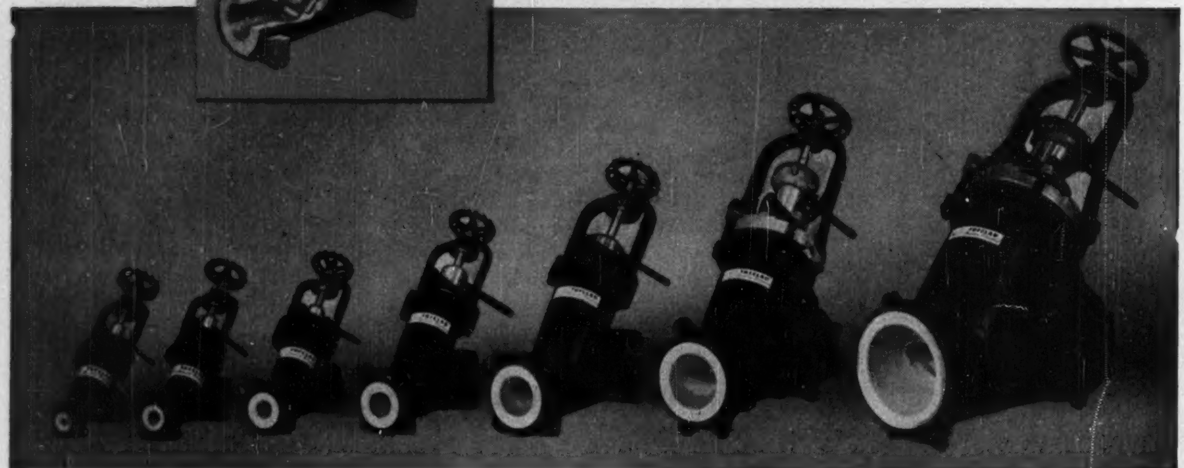
1033

INCORPORATED

DOMESTIC DIVISIONS: Hewitt Rubber • Robins Conveyors • Robins Engineers • Restfoam
FOREIGN SUBSIDIARIES: Hewitt-Robins (Canada) Ltd., Montreal • Hewitt-Robins Internationale, Paris, France • Robins Conveyors (S. A.) Ltd., Johannesburg • **EXPORT DEPARTMENT:** New York City.



PRIMARY PROTECTION FOR PERSONNEL . . . EQUIPMENT . . . PRODUCT . . .



Y-Valves, as shown, and Angle Valves are available in Lapp TUFCLAD Chemical Porcelain in ½", 1", 1½", 2", 3", 4" and 6" sizes. Also safety valves, flush valves, plug cocks, pipe and fittings (to 8" dia.) and special shapes.

Lapp TUFCLAD®

SOLID Chemical Porcelain ARMORED with Fiberglass-Reinforced Plastic

What's your first worry in case of minor fire or explosion or accident? You can get a big one off your mind with installation of Lapp Chemical Porcelain with TUFCLAD Fiberglass-reinforced plastic. Without special construction for protection, you have all the advantages of a solid porcelain system with extra security for personnel, equipment and product.

TUFCLAD provides a cushion to protect porcelain against accidental damage in handling or operation—and as insulator against thermal shock. And the TUFCLAD shell is of itself *tough*—fully able to hold operating pressures against gross leakage even though porcelain is damaged by accident, explosion or fire.

WRITE for description and specifications. Lapp Insulator Co., Inc., Process Equipment Division, 706 Maple St., Le Roy, N. Y.

Lapp

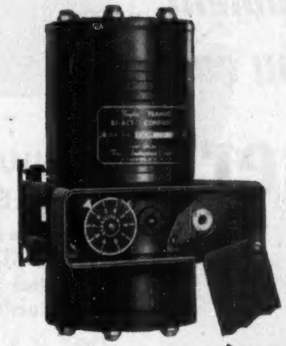
PROCESS EQUIPMENT

CHEMICAL PORCELAIN VALVES • PIPE • RASCHIG RINGS

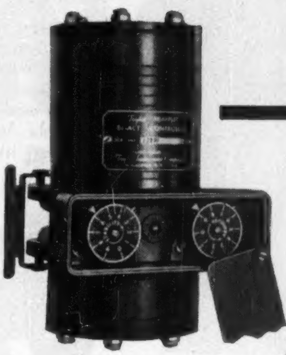
PULSAFEEDER CHEMICAL PROPORTIONING PUMPS

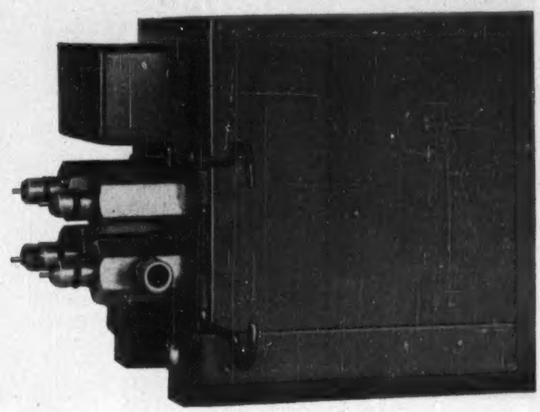
Plug-in feature fits all 3

One-knob BI-ACT, two-knob BI-ACT and TRI-ACT* Controllers completely interchangeable on TRANSET* Indicators, Recorders and field-mounted manifolds, thanks to universal PLUG-IN feature.*

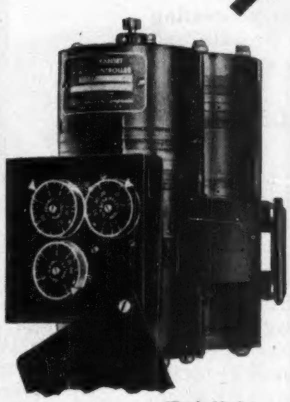


The one-knob BI-ACT Controller is designed for use in industrial processes with short time lags, such as close-coupled liquid flow, fast pressure and comparable temperature problems. Combines simplicity of adjustment and economy.





The two-knob BI-ACT Controller will cover the full range of reset rate and proportional response adjustments. This makes it more satisfactory for those jobs that have longer time lags, and where close response adjustments are essential to good performance.



The brand new TRI-ACT Controller combines all three response adjustments (gain, reset rate and Pre-Act response). It is the most complete controller, giving the very best control on the more complex processes, particularly those with long time constants, and load changes requiring both derivative and reset adjustments. Gives faster recovery on load changes; start-up without overpeaking; the benefits of automatic reset without its evils.

*Trade-Mark

Instruments for indicating, recording and controlling temperature, pressure, flow, liquid level, speed, density, load and humidity.

Plug-in, Taylor's new idea in panel instrumentation gives you simplicity of installation and maintenance; economy in installation and in panel space; and minimum down time for maintenance.

You can change from the simplest to the most complete control, or from indicator to recorder or vice versa, by simply unplugging one unit, plugging in another—in a matter of seconds. Only one simple rectangular panel opening is required for mounting both controller and receiver (recorder or indicator). Does not require welding or drilling of holes.

Only 3 piping connections required: air supply, controller output and variable transmitter. All other connections are made automatically, in the self-sealing manifold.

Panel space is not only reduced by plug-in feature, but adjustments and maintenance are even more convenient.

Write for full information on Taylor Plug-In TRANSET Control—it may well be the answer to your problem. Taylor Instrument Companies, Rochester, N. Y., and Toronto, Canada.

Taylor Instruments mean ACCURACY FIRST

Wide Experience

in precision processing equipment is at your command when you call

Proctor Engineers

When you sit down with Proctor engineers to discuss processing equipment you are availing yourself the benefit of a breadth and depth of experience that is virtually unequaled in any other single equipment manufacturer.

The result—carefully designed, well built equipment that will meet *precisely* the need for which it is created.

Proctor project engineered equipment is operating today in all branches of the process industries—heavy chemicals, pharmaceuticals, food, leather, tanning, synthetic textiles, rubber manufacturing, plastics and many more.

With their wide range of experience in building individually designed drying and fiber processing machinery—Proctor engineers are well equipped to apply their skill to developing, engineering and manufacturing *other processing machinery.* This machinery may be related to drying equipment and used in the same range—or it may be totally unrelated but require the same basic kind of engineering and manufacturing skill.

Calling on Proctor engineers is the shortest way to the surest solution to your processing equipment problem. If you have such a problem—write us today in as much detail as possible and you will see what we mean.

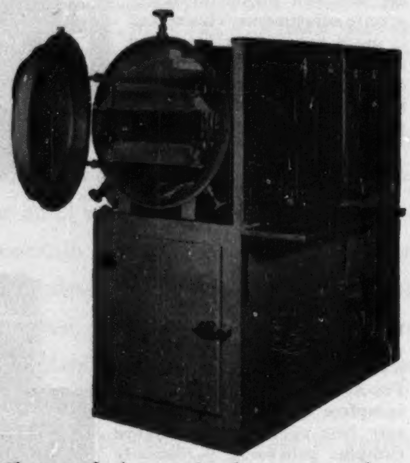
PROCTOR CREATIVE ENGINEERING AT WORK

THE PROCTOR VACUUM-RADIANT HEAT FREEZE DRYING SYSTEM

Utilizes selective absorption radiant heat which results in shorter drying cycles, increased production and improved product.

Here is a patented method for drying heat sensitive materials, while frozen, that is finding wide application in drying products which must remain unchanged chemically or biologically after drying.

By taking advantage of the fact that every substance, including water, absorbs only certain wave lengths of radiation and is transparent to others, the Proctor freeze drying unit reduces drying cycles to as little as ¼ or ⅓ the length of time required by conventional freeze drying.



Shorter drying cycles increase production, and are of decided advantage in drying materials containing living organisms. In conventional freeze drying the heat of sublimation is supplied by conduction and is much slower and not as uniform. The principle of "selective absorption radiant heat" is the greatest advance in freeze drying in years—and is yours in the Proctor unit.

Proctor freeze drying equipment of this type may be supplied in the form of a research unit, a commercial batch unit or a continuous system. Write for details.

PROCTOR & SCHWARTZ, INC.
711 Tabor Road • Philadelphia 20, Pa.
[illegible] ENGINEERS AND MANUFACTURERS OF [illegible]

For many years this non-toxic acid has served as the leading organic acidulant in foodstuffs ...beverages, candies, jellies, desserts. Now, more and more industries are finding Pfizer Citric Acid and its derivatives ideal for a variety of processes far-removed from the "kitchen."

Take metal finishing for example. Because it removes oxide films with a minimum loss of virgin metal, you'll find Citric Acid used in polishing and cleaning processes. Di Ammonium Citrate is finding increasing use in the removal of iron contamination from stainless steel and rust scale from iron surfaces.

Because it forms water soluble complexes with metallic ions such as iron and aluminum, Pfizer Citric Acid serves as an excellent sequestering agent in processes where metals precipitating out of solution cause trouble...industrial water treatment, leather tanning, edible oil production, 2,4-D formulations.

Since it contains one hydroxyl and three carboxyl groups, Citric Acid as an intermediate for organic synthesis offers many interesting possibilities. And, esters of Citric Acid...several of them marketed commercially by Pfizer...offer the plastics industry non-toxic plasticizers with a range of desirable characteristics.

These varied applications may suggest mild, versatile citric as an acid or intermediate in your processing. For additional information, write:

Versatile

is the Word for

CITRIC ACID

Check These Industrial Uses

CHAS. PFIZER & CO., INC.
630 Flushing Ave., Brooklyn 6, N.Y.
Branch Offices:
Chicago, Ill.; San Francisco, Calif.; Vernon, Calif.; Atlanta, Ga.

Manufacturing Chemists for Over 100 Years **Pfizer**

BIG NEWS IN ALUMINUM!

48" Wide Embossed Industrial Corrugated

...For Lower Installed Cost, Improved Appearance!

All the advantages that have made Reynolds Aluminum Industrial Corrugated a sweeping success throughout industry...rust-proof permanence, lowest maintenance, high insulation...now at even lower installed cost and with improved appearance! With these new 48" sheets, side laps take 30% less metal, 30% fewer fasteners...and there are 30% fewer sheets to handle. With the new stipple-embossed finish, the wider-spaced laps tend to disappear...making a handsome, uniform, textured effect. Call on Reynolds for literature, technical and application details.

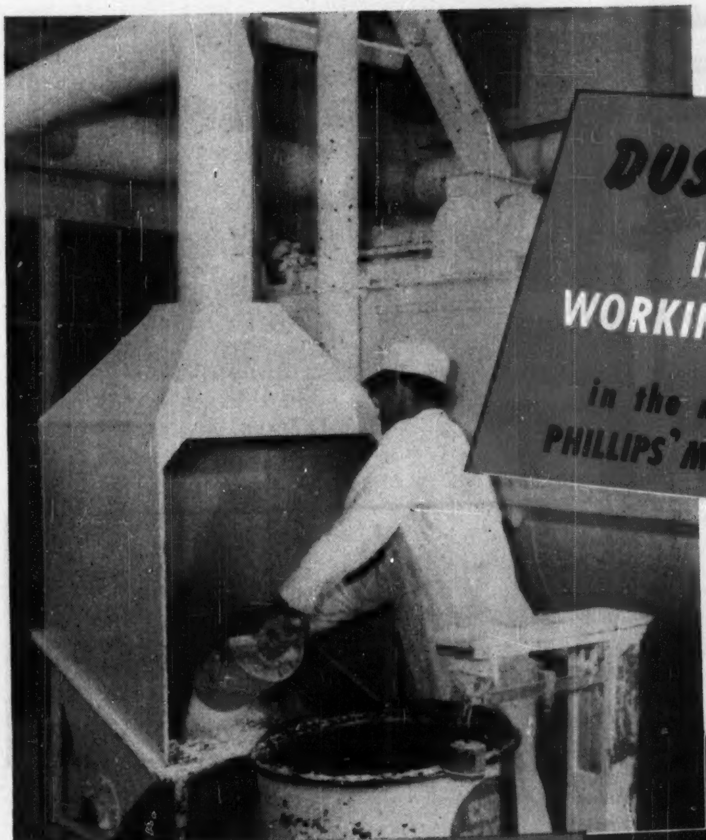
Offices in principal cities. Check your classified phone book for our listing under "Building Materials." Or write Reynolds Metals Company, Building Products Division, 2020 South Ninth St., Louisville I, Kentucky.

DESCRIPTION:
METAL THICKNESS: 0.032 inch (22 U.S. Std. Ga.)
FINISH: Embossed.
LENGTHS: 5', 5' 6", 6', 6' 6", 7', 7' 6", 8', 8' 6", 9', 9' 6", 10', 10', 6", 11', 11' 6", 12'. (Special lengths cut to order subject to inquiry.)
WIDTH: Over all width 48⅓", nominal coverage 45⅓", 1½ corrugations side lap.
CORRUGATION: Pitch 2.667" center to center, depth ⅞", 18 crowns, 18 valleys, one edge up, opposite edge down.
WEIGHT: 56 pounds per 100 square feet of formed sheet.

Standard .032" mill finish Industrial Corrugated also available—35" width, same lengths as above.

REYNOLDS *Lifetime* ALUMINUM INDUSTRIAL CORRUGATED

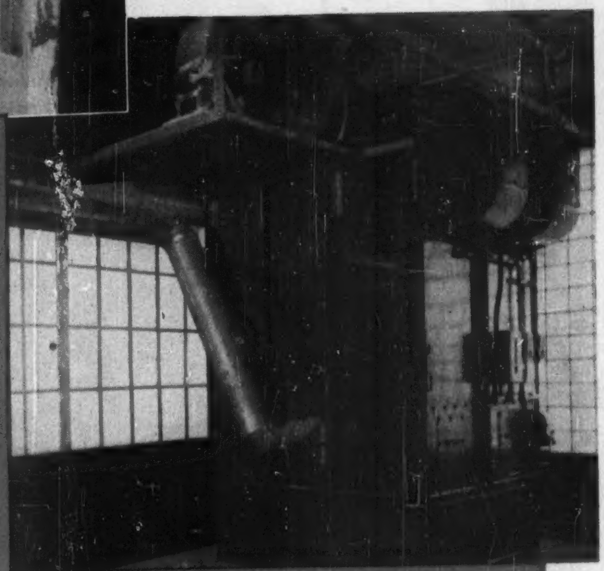
SEE "Mister Peepers," starring Wally Cox, Sundays, NBC Television Network. HEAR "Fibber McGee and Molly," Tuesdays, NBC Radio Network.



DUSTUBE® collector

IMPROVES WORKING CONDITIONS

in the manufacture of PHILLIPS' MILK OF MAGNESIA



PROBLEM: The fine pharmaceutical powders used by The Chas. H. Phillips Co., Div. of Sterling Drug, Inc., created a serious dust problem in the tablet making and packaging room operations. The dust laden air settled throughout the room — a source of annoyance to the workers plus increasing plant housekeeping efforts and decreasing efficiency of the necessary air conditioning system.

SOLUTION: A high efficiency Dustube cloth-tube-type dust collector was installed to ventilate all mixing, tableting and packaging operations in processing Milk of Magnesia.

RESULTS: In the words of Mr. R. Ross Kitchen, Plant Manager, "The Dustube Collector has proved satisfactory from the standpoint of improved working conditions, reduced cleaning of department and a definite lengthening of the life of the air-conditioning system. (Time required to clean this unit reduced 75% — man hours from 21 to 5 hours.)"

Such outstanding performance is not unusual. It's the kind of efficiency and operating economy that may be expected from Dustube Collectors. Get the facts about what they can do on your dust or fume job.

Send today for Bulletin 372 and the address of your nearest Dustube field engineer.

American

WHEELABRATOR & EQUIPMENT Corp.

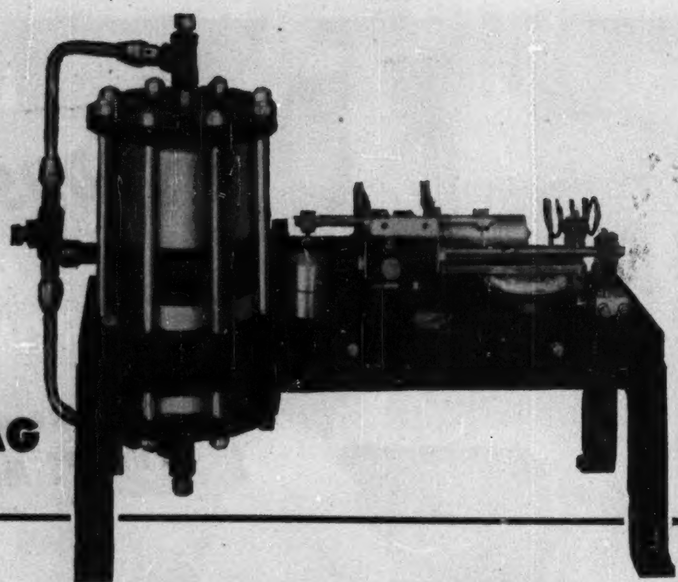
347 S. Byrkit St., Mishawaka, Indiana

dustube® COLLECTORS

MEASURES DENSITY

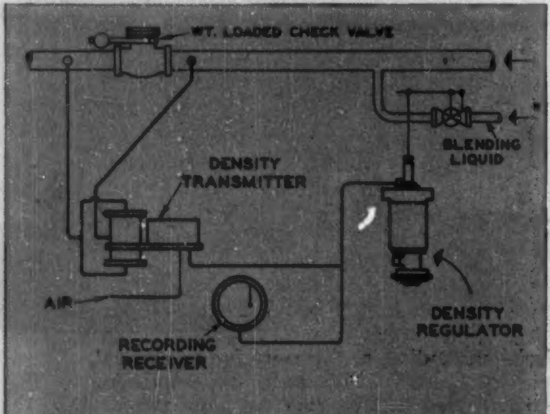
of flowing liquids

with MINIMUM LAG



Republic DENSITY TRANSMITTER

- **Makes a Continuous Density Measurement at Line Pressures to 300 psig.**
- **Transmits Air Loading Pressure Proportional to Flow Density to Remote Reading Instruments and Control Devices.**



Here's How Transmitter is Used to Control Blending of Lubricating Oil

Continuous measurement of flow assures prompt detection of density changes . . . permits corrections while liquid is still in flow line. There's no intermittent sampling to cause errors or lags.

Transmitter is all metal; contains no glass tubing to limit its application to very low pressures. For corrosion resistance, transmitter can be furnished in a wide variety of metals including nickel.

Narrow range spreads as small as 0.05 equivalent specific gravity for extreme accuracy of measurement are available. Accuracy is guaranteed to 1/2 of 1% of range spread for all ranges.

Get all the facts about this instrument. It's fully described in Data Book 1004. Write for your copy now.

REPUBLIC FLOW METERS CO.
2240 Diversey Parkway, Chicago 47, Illinois

New BROCHURE!

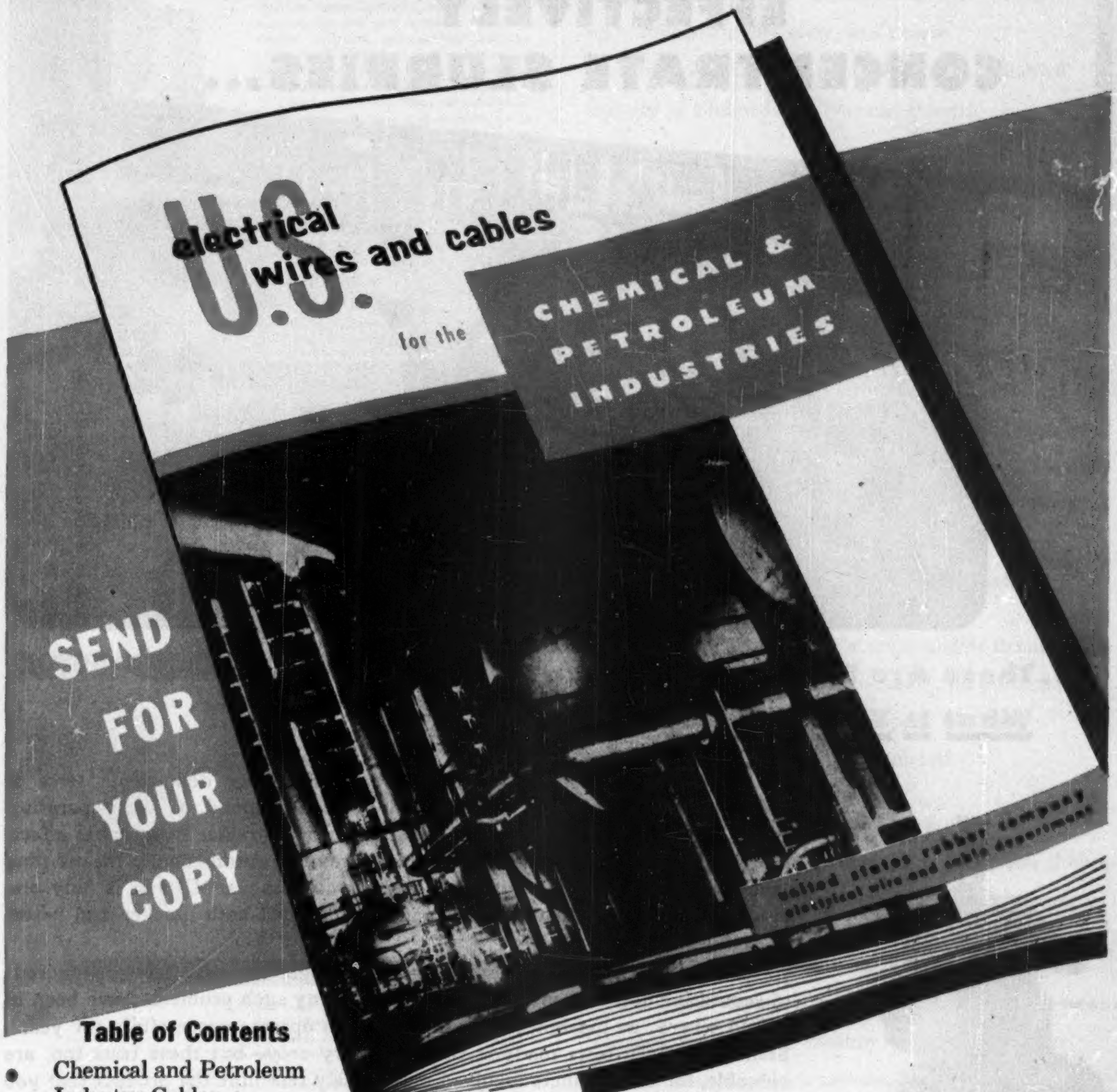


Table of Contents

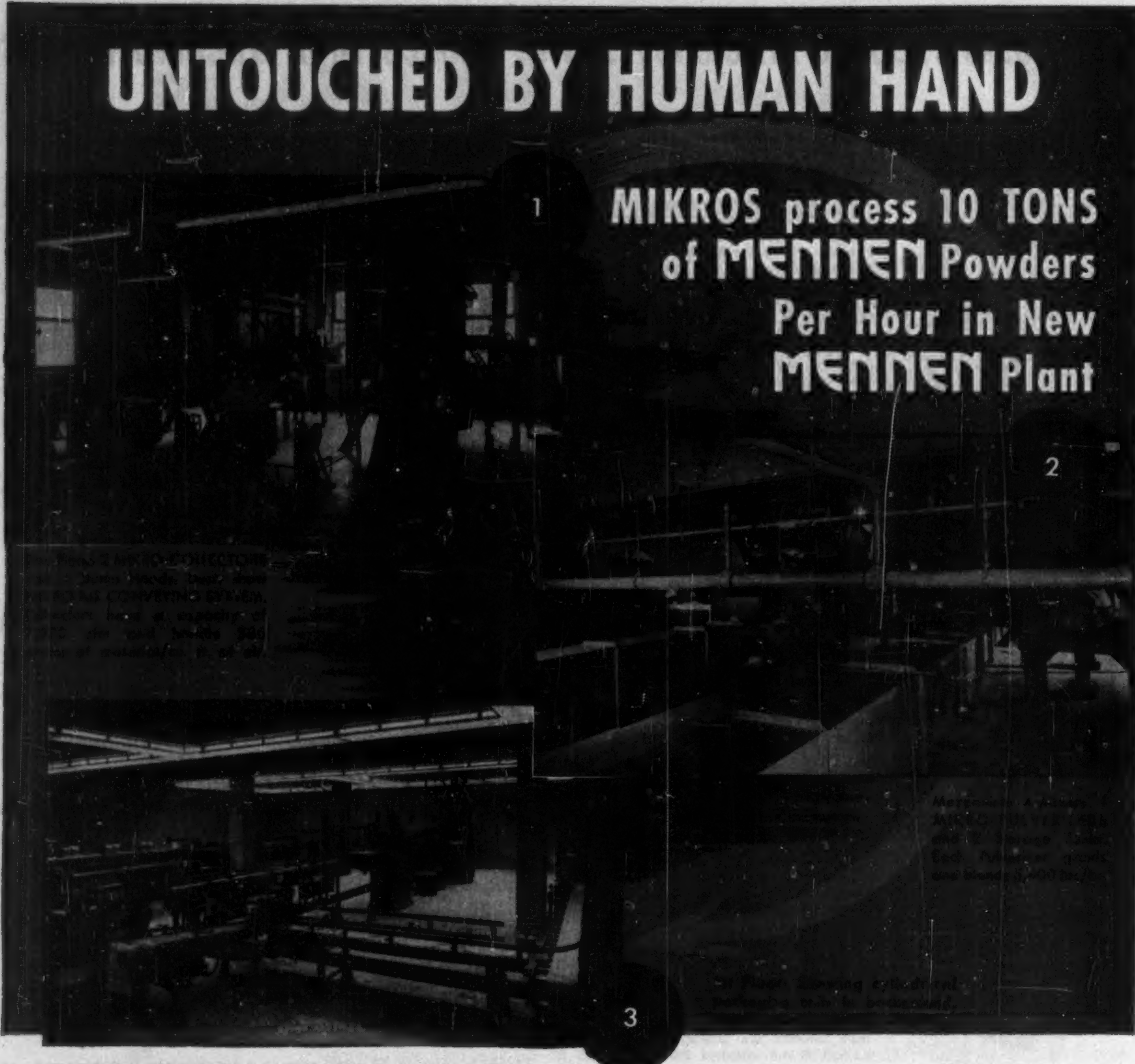
- Chemical and Petroleum Industry Cables
- Insulation Compounds
- Jacket Compounds
- Portable Cables
- Power Cables
- Control Cables
- Telephone Cables
- Tables

Electrical Wire and Cable for the Chemical and Petroleum Industries must have the right chemical, oil and corrosion-resistant insulations plus the right electrical and physical properties for the job. Insulations and jackets which may be excellent for one type of service may be unsatisfactory in another. United States Rubber Company, a specialist in manufacturing the *right* electrical wires and cables for the Chemical and Petroleum Industries, is the only wire and cable manufacturer growing its own natural rubber, making its own synthetic and plastic insulations.

The brochure shown above shows what "U.S." wires and cables to order for specific applications. Write to address below for your free copy.

UNITED STATES RUBBER COMPANY

ELECTRICAL WIRE AND CABLE DEPARTMENT • Rockefeller Center, New York 20, N. Y.



The name of Mennen stands for quality. So does the trade name MIKRO. It was only logical then, that the two should inspire the creation of a continuous processing system unique in the field of cosmetics, at the new Mennen plant in Morris Township, N. J. The MIKRO-designed process gave Mennen precisely what they wanted—extreme cleanliness and freedom from dust and contamination in grinding, blending and packaging. Material is moved through the MIKRO Air Conveying System so smoothly and automatically that the human hand need only push buttons.

The grinding and blending is done by four No. 2TH MIKRO-PULVERIZERS whose product reveals its finely ground and blended texture under a strong microscope.

Two MIKRO-COLLECTORS*, each containing 8 felt filter cylinders vent every unit in the system, while maintaining uniform pressure. Their phenomenal filter rates insure high capacity and complete product recovery, along with freedom from dust.

Thus the MIKRO method has given The Mennen Company not only the high quality they demand but peak production with economy in manpower, motorpower and maintenance.

WRITE FOR illustrated descriptive literature.

*Patents Applied For by H. J. Hersey, Jr. and Pulverizing Machinery Company

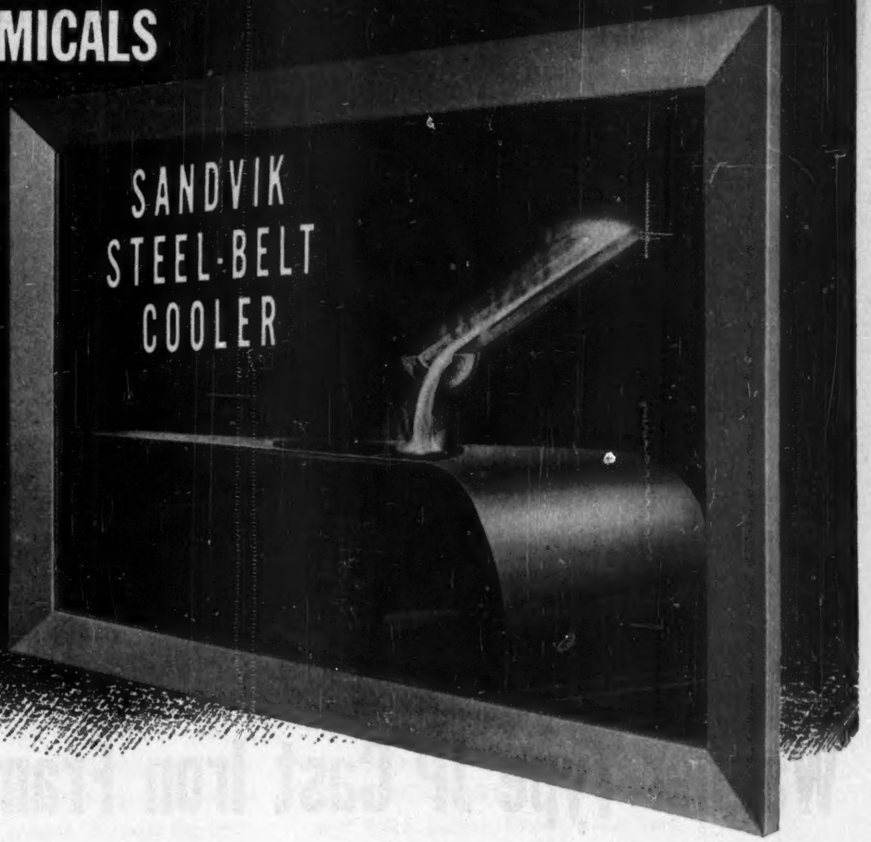
2124

MIKRO-PULVERIZER (FINE)
-ATOMIZER (ULTRA FINE)
-COLLECTOR (100 PER CENT)
REG. U.S. PAT. OFF.

PULVERIZING MACHINERY COMPANY
55 Chatham Road • Summit, New Jersey

PRESERVE OUR HERITAGE: FAITH, FREEDOM AND INCENTIVE

Picture of A CONTINUOUS WAY TO PROCESS HOT* CHEMICALS



* Materials With Temperature Up to 1900° F. Are Being Sucess-fully Handled. Tests Indicate Possibility Of Handling Even Hotter Materials

Here's a way to engineer efficient, continuous-cooling or conveying into your hot material processing.

Sandvik's steel-belt continuous coolers carry the material on a solid, endless, steel band of flat, stainless or carbon steel. This band "floats" on a patented water-bed arrangement which cools from beneath . . . no water gets on top of the band.

You can cool and convey, regulate thickness and graduate temperature while cooling, obtain desired sizes in the same operation, cool and strip off gelatinous materials in sheet form, cool loose and pulverized materials, cool solids in sheet form or crystallize liquids.

A steel belt provides a smooth, hard, impervious surface that is easy to keep clean. It has a high load capacity and a long service life. It can be fitted with simple discharge devices that scrape material off at any point. It can be of any length or width.

Sandvik steel belt units *without* the patented water-bed cooling arrangement can be used for other chemical processing functions such as drying, evaporating, conveying, carrying material through ovens, etc.

ENGINEERING SERVICE—Sandvik's engineering department will be glad to work with you in designing a conveyor to fit your operation. Sandvik has had over thirty years of experience in designing units to operate either as independent units or as integral parts of special processing equipment.

Write, wire or phone for further information.

SANDVIK STEEL, INC., • CONVEYOR DIVISION
111 Eighth Ave., New York 11, N.Y. WAtkins 9-7180

SS-89

SANDVIK STEEL BELT CONVEYORS

PILOT SCALE UNITS AVAILABLE FOR TEST PURPOSES

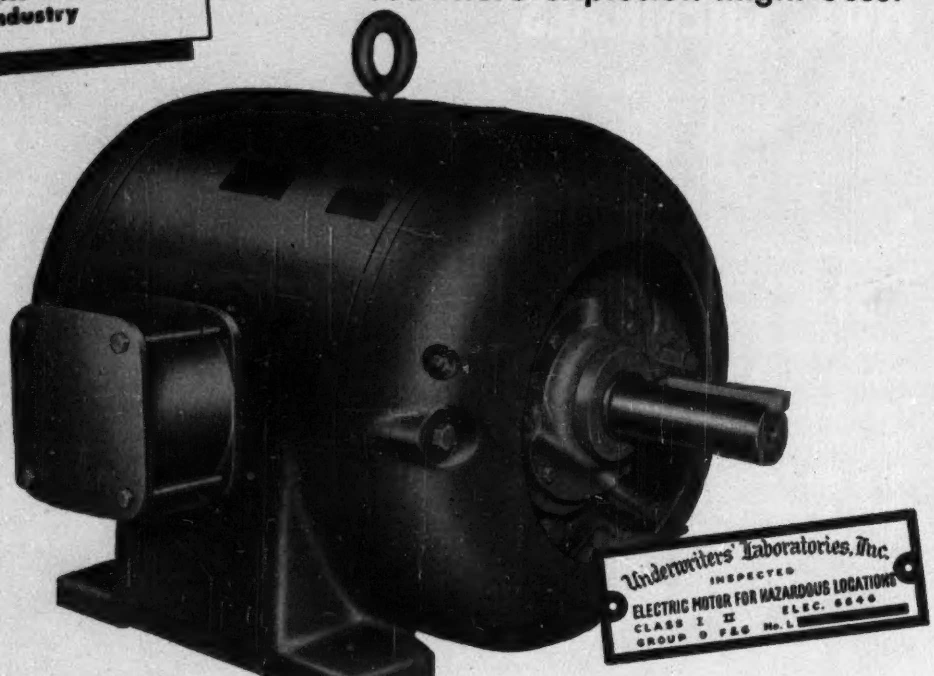
Experimental units are available to help you determine cooling rates and other data for your specific material.


Water-bed Section Test Tank


Complete Experimental Water-Bed Belt Cooler

Wagner
ELECTRIC MOTORS
...the choice of leaders in industry

...where corrosion is a problem
...where explosion might occur



Wagner Type JP Cast Iron Frame Motors

Wagner type JP cast iron frame motors are built for use in chemical plants, oil fields, refineries, steel mills—for any application where corrosive and explosive conditions might prevail.

These rugged motors are totally-enclosed in rust- and corrosion-resistant cast iron. They are fan-cooled by an externally mounted blower, made of non-sparking bronze, that forces air through ventilating passages in the frame. They feature completely protected laminations . . . special varnish treated windings . . . a running shaft seal . . . and an explosion-proof conduit box with machined fits.

A standard type cast iron frame motor (for applications where protection against explosion is not required is also available. Both types are built in ratings from 2 to 250 hp, with either normal or high torque characteristics.

Wagner Bulletin MU-132 gives complete information on these protected motors. A nearby Wagner engineer can help you select a Wagner Motor to meet your most exacting specifications. Consult the nearest of our 32 branch offices, or write us.

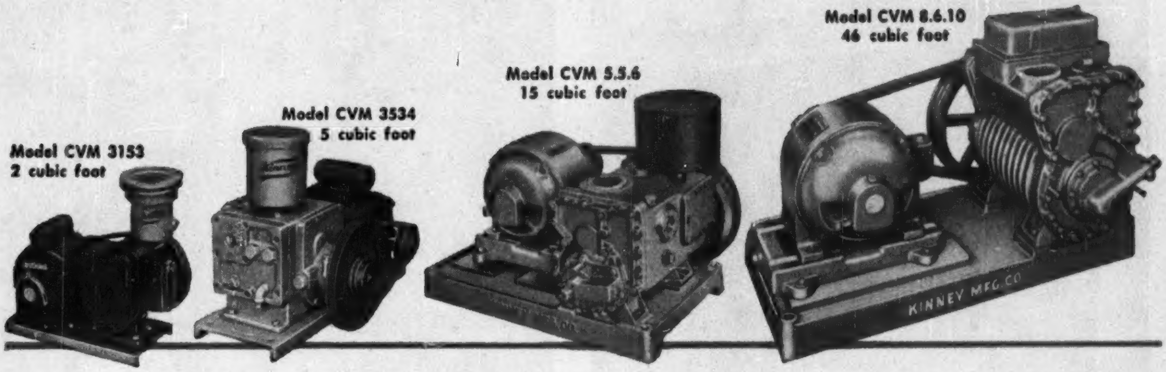
Wagner Electric Corporation
EST. 1891

WAGNER ELECTRIC CORPORATION
6407 Plymouth Ave., St. Louis 14, Mo., U.S.A.

ELECTRIC MOTORS · TRANSFORMERS · INDUSTRIAL BRAKES
AUTOMOTIVE BRAKE SYSTEMS — AIR AND HYDRAULIC

BRANCHES IN 32 PRINCIPAL CITIES

M53-9



COMPOUND VACUUM PUMPS

ONE pump casing . . . ONE motor and drive shaft . . . TWO pumping chambers connected in series — this is the basic design of the Kinney Compound Vacuum Pump. Built in four sizes — with 2, 5, 15, and 46 cu. ft. per min. displacements — the Kinney Compound Vacuum Pump fills an important place in high vacuum systems. Because the Compound Pump pulls to 0.2 micron or better, it often handles the complete vacuum job without diffusion pumps or mercury vapor pumps. Each pump retains better than 50% of its theoretical pumping speed right into the less-than-one-micron zone . . . assures fast pump down for most efficient utilization of processing time. Each pump provides the low-maintenance, high-efficiency operating advantages that have made Kinney Vacuum Pumps the first choice of Industry. They are easy to service . . . no special tools are required.

Experienced vacuum engineers, here in Boston and in our branch offices, will be glad to discuss the application of vacuum in your plant. KINNEY MANUFACTURING CO.— manufacturers of vacuum and liquid pumps. Boston, New York, Chicago, Detroit, Cleveland, Atlanta, Philadelphia, Pittsburgh, Los Angeles, Charleston (W. Va.), Houston, New Orleans, San Francisco, Seattle, and foreign countries.

SEND COUPON FOR DETAILS!

★ SUBSIDIARY OF THE NEW YORK AIR BRAKE CO. ★

Kinney

KINNEY MANUFACTURING COMPANY
3551 Washington Street, Boston 30, Mass.

Send Bulletin V-51B describing complete line of Kinney Vacuum Pumps.

Name..

Company..

Street..

City.................... State....................

infra-red analysis *tells how much of a selected component exists in gas mixtures. Here, continuous analysis recorded by an ElectroniK potentiometer on a refinery's graphic panel is used for actual process control.*

mass spectrometry *separates materials on the basis of their different molecular weights . . . finds what constituents are present in what quantity. Above is a "package" mass spectrometer in which an ElectroniK instrument records test data.*

gas analyzer, *operating on the thermal conductivity principle, combines an ElectroniK recorder, analysis cell and accessories in a single panel assembly.*

New concepts *utilize*

These are some of the manufacturers who use *ElectroniK* instruments in their analyzers

Products of the companies checked are illustrated on these pages

Applied Research Laboratories
Baird Associates
Bausch and Lomb
Beckman Instruments, Inc.
Consolidated Engineering Corporation
✓ Davis Emergency Equipment Co.
✓ General Electric Co.
Jarell-Ash
Mine Safety Appliances Co.
North American Philips Co., Inc.
Perkin-Elmer Corp.
✓ Podbielniak, Inc.
Precision Scientific Co.
E. H. Sargent & Co.
Tracer Laboratories
✓ Applied Physics Corp.

robotized distillation apparatus *determines composition of hydrocarbon mixtures in minutes instead of hours. The temperature versus volume-distilled curve drawn by the ElectroniK potentiometer needs no replotting for computing analysis.*

# of process control

ElectroniK instruments

From the analytical laboratory comes a new concept of industrial process control, based directly on the desired chemical or physical characteristics of the product.

Continuous analyzers now make it possible to measure composition of gases and liquids accurately and automatically . . . to record this information . . . even to actuate automatic controls. Instead of temperature, pressure and flow, these new systems deal in terms of refractive index, density, ultraviolet and infrared spectra, radiation intensity and absorption.

An essential component of all these systems is automatic recording. To fill this critical function, leading manufacturers of automatic analyzers choose *ElectroniK* instruments. They choose them for their exceptional accuracy, that exploits fully the inherent precision of the new measuring techniques. They choose them, too, for sensitivity that records every essential change in readily readable detail. And they prefer *ElectroniK* recorders for their simple, rugged design that guarantees dependable service under any industrial conditions.

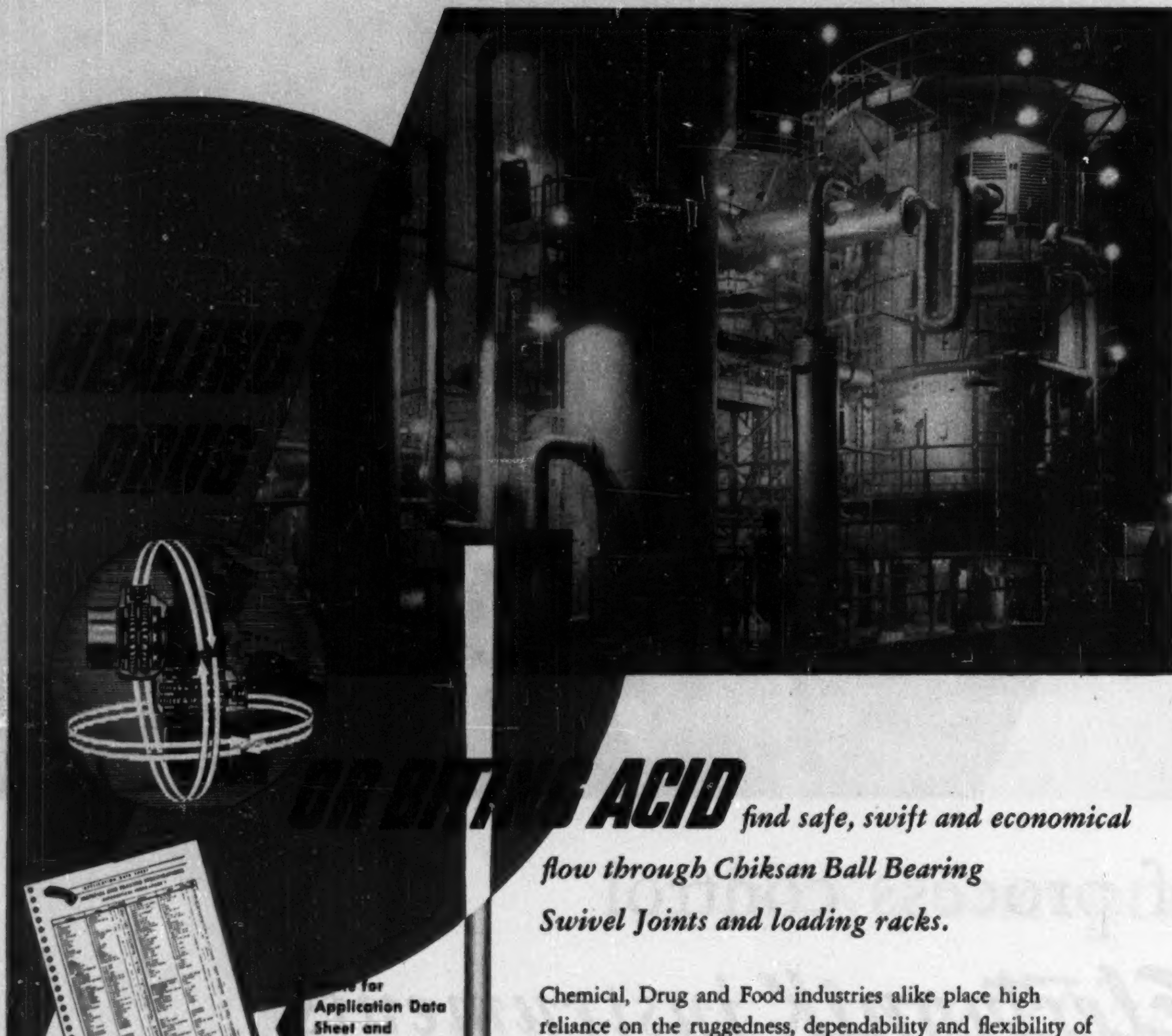
Your local Honeywell engineering representative will be glad to discuss the role of *ElectroniK* instruments in product-analysis systems . . . or in any conventional process control. Call him today . . . he is as near as your phone.

Minneapolis-Honeywell Regulator Co., *Industrial Division*, 4478 Wayne Ave., Philadelphia 44, Pa.

● **REFERENCE DATA: Write for Bulletin 15-14, "Instruments Accelerate Research."**

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS

First in Controls


OR BITING ACID find safe, swift and economical flow through Chiksan Ball Bearing Swivel Joints and loading racks.
for Application Data Sheet and Catalog 53-C Dept. No. CE-6
Whether it's propane, butyl alcohol, vegetable oils or sulphuric acid, CHIKSAN loading racks with ball bearing swivel joints can be depended upon to handle these hard to handle chemical products with ease, economy and complete safety.
Chiksan has material and packing specification sheets listing 317 chemical products with recommendations for types of joints, metal and packing material to be used.
Chemical, Drug and Food industries alike place high reliance on the ruggedness, dependability and flexibility of Chiksan Ball Bearing Swivel Joints.
In packing plant, paper mill, laboratory and drug manufacturing, harsh acid, fine-tasting foodstuffs and benign medicines find a swift, safe passage through flexible lines in processing, testing, bottling or packing — thanks to the heat, cold, and pressure-resisting characteristics of Chiksan Ball Bearing Swivel Joints.
From penicillin to paper making, CHIKSAN loading racks with Ball Bearing Swivel Joints, can handle practically all types of salts, acids, alcohols, glycols, aldehydes, alkaline solutions, animal oils, aromatics, chlorine derivatives, volatile gases and soaps.
The Flow of Enterprise Relies on
CHIKSAN
CHIKSAN
Ball-Bearing Swivel Joints
Representatives in Principal Cities
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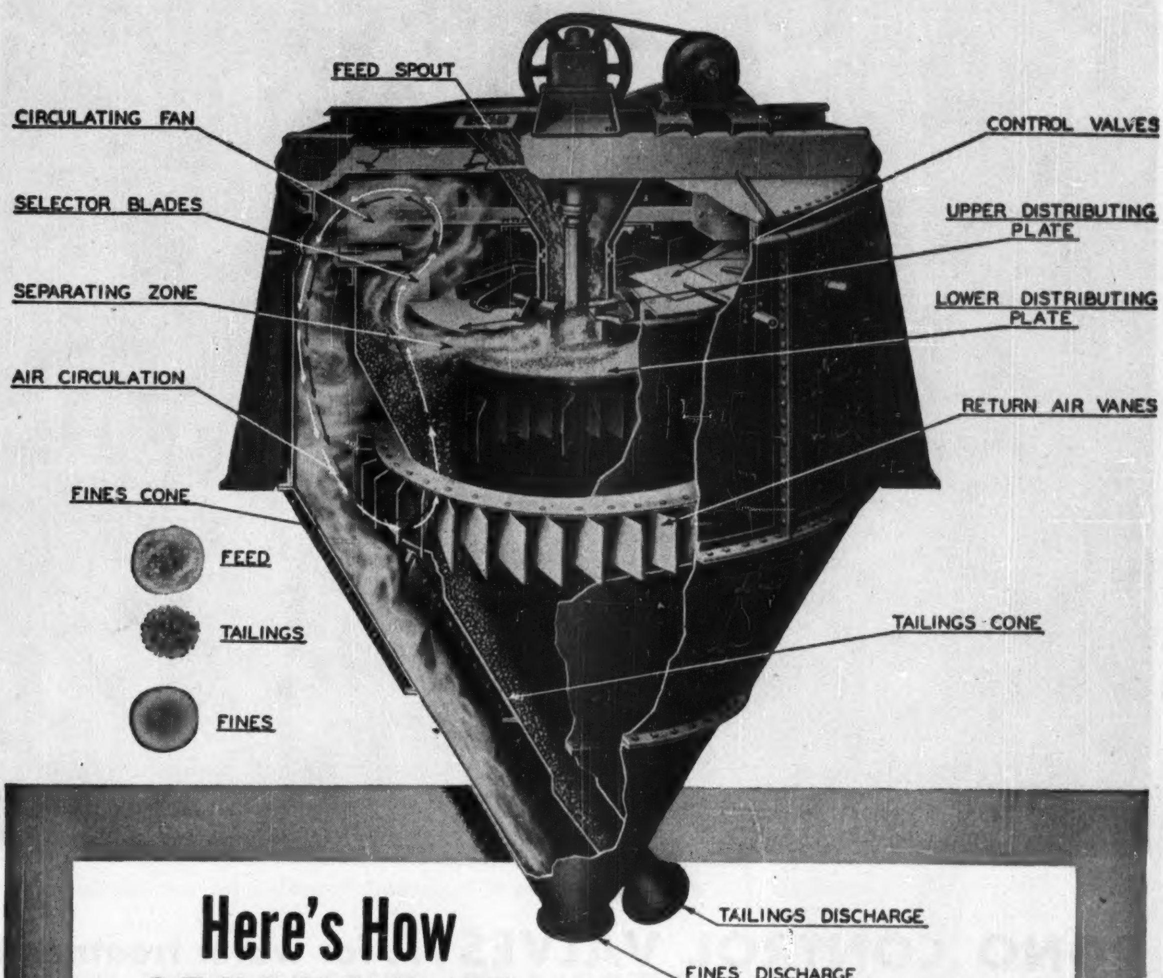
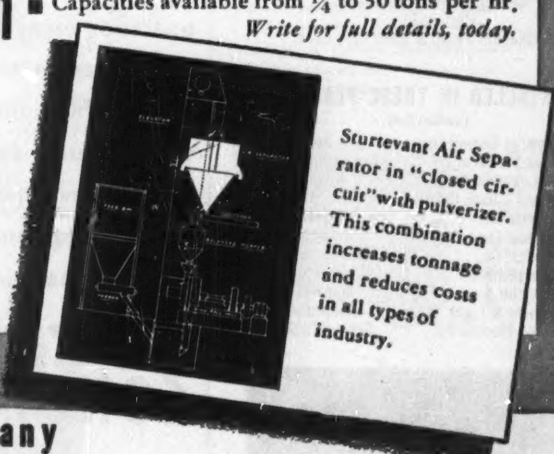
Well Equipment Mfg. Corp. (Division), Houston 1, Texas • Chiksan Export Company (Subsidiary), Brea, California • Newark 2, N. J.



Here's How STURTEVANT Air Separators Increase Production of Fines . . . Lower Separation Costs

- Sturtevant Air Separators effect production savings by increasing output by 25 to 300% . . . reducing power consumption by as much as 50%.
- They efficiently carry off all classified materials in any desired fineness from 40 to 325 mesh and finer . . . eliminate the need of screening in certain applications.
- Capacities available from 1/4 to 50 tons per hr.

Write for full details, today.



Sturtevant Mill Company
100 Clayton Street, Boston 22, Mass.

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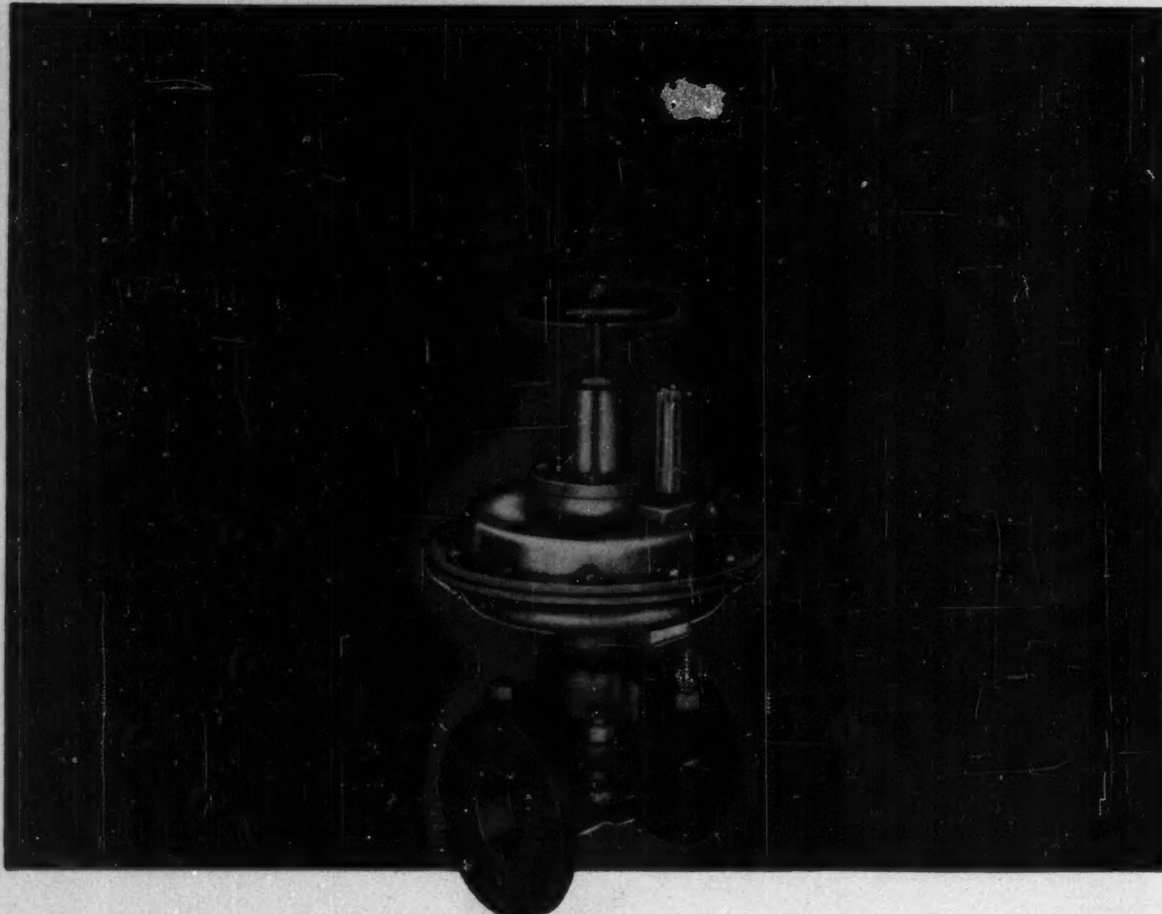


CONO CONTROL VALVES . . . for water treatment

SPECIFIED BY THESE FIRMS
(partial list)

American Cyanamid—Ion Exchange Div.
Belco Industrial Equipment Div., Inc.
Cochrane Corporation
General Filters, Inc.
Graver Water Conditioning Co.
Illinois Water Treatment Co.
Permutit Co.
Worthington Pump & Machinery Corp.

INSTALLED IN THESE PLANTS
(partial list)

Atomic Energy Commission	Arco, Idaho
J. T. Baker Chemical Co.	Phillipsburg, N. J.
Blockson Chemical Co.	Joliet, Illinois
Consolidated Edison Corp.	New York
Dow Chemical Co.	Freeport, Texas
Dow Chemical Co.	Velasco, Texas
Dow Chemical Co.	Pittsburg, Calif.
Gulf States Utilities	Baton Rouge, La.
Johns-Manville	Manville, N. J.
Penna. Power & Light	Shawmont, Pa.
Philadelphia Electric Co.	Schuylkill Station

Cono Close Coupled Pneumatic Control Valves provide unbroken service day in, day out—year in, year out—in the automatic operation of demineralizers and other process systems. Hundreds of Conoflow valves, like those shown here, have been in operation many years without maintenance or repair. Cono Control Valves are available in assemblies for on-off service (guaranteed bubble-tight shut off) or for throttling control. Available with optional features such as handwheel type limit stops as shown, plastic position indicators, and micro-switch attachments for actuating remote visible or audible signals. Body sizes up to 12" in all materials—rubber lined, Saran lined, alloys, etc.

Write or phone for Conoflow's usual personalized attention.

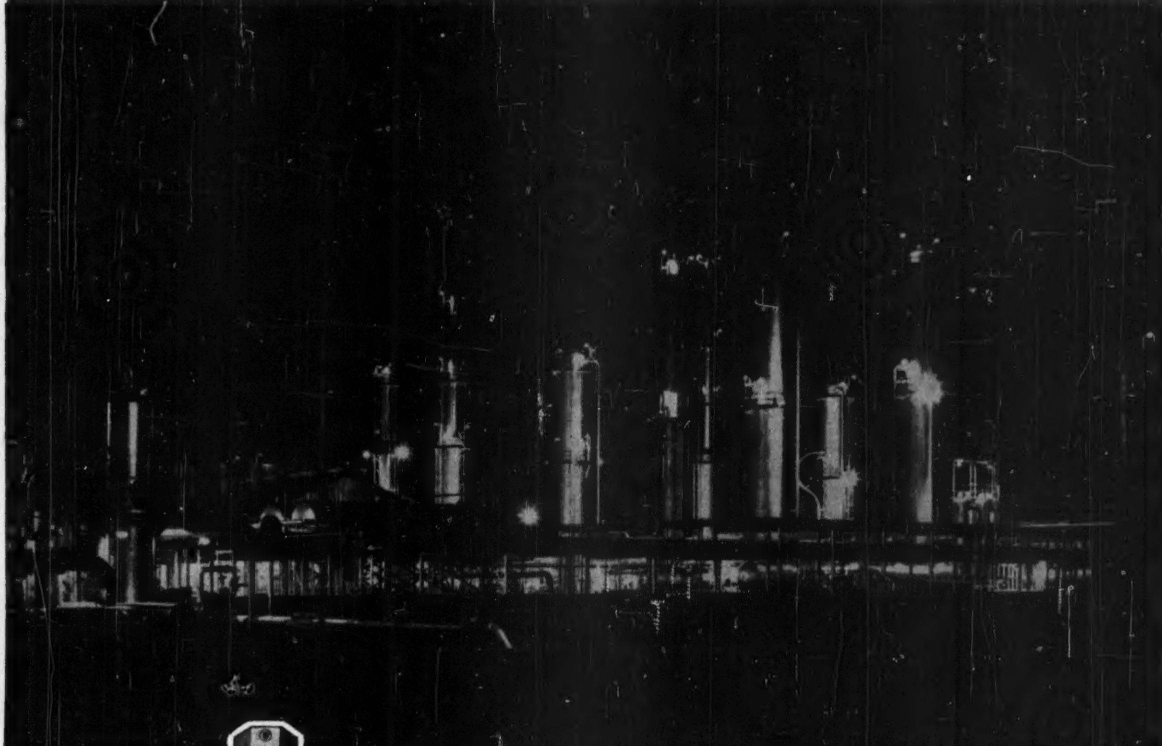
CC-900

CONOFLOW CORPORATION

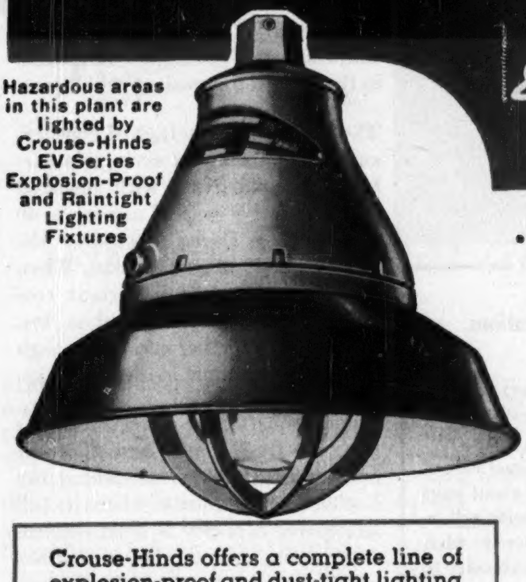
Foremost Manufacturers of Final Control Elements

2100 ARCH STREET, PHILADELPHIA 3, PENNSYLVANIA

CROUSE-HINDS



Explosion-Proof
LIGHTING FIXTURES



Hazardous areas in this plant are lighted by Crouse-Hinds EV Series Explosion-Proof and Raintight Lighting Fixtures

... EXCEED the requirements for service in highly explosive atmospheres

To be safe for use in such locations, the fixture must operate at a temperature below the ignition temperature of the gas-air or vapor-air mixture. Also, the fixture must be so strong that it will resist internal explosions without damage and so tight that it will prevent the escape of flames or burning gases which might ignite the surrounding atmosphere.

Crouse-Hinds EV Series explosion-proof and raintight industrial lighting fixtures meet all of these requirements PLUS a wide margin of safety for extra protection.

Complete listings are in Crouse-Hinds Condulet Catalog.

Crouse-Hinds offers a complete line of explosion-proof and dust-tight lighting fixtures for use in hazardous locations where fluorescent lamps are desired.

CROUSE-HINDS COMPANY
Syracuse 1, N. Y.

OFFICES: Birmingham — Boston — Buffalo — Chicago — Cincinnati — Cleveland — Dallas — Denver — Detroit — Houston — Indianapolis — Kansas City — Los Angeles — Milwaukee — Minneapolis — New Orleans — New York — Philadelphia — Pittsburgh — Portland, Ore. — San Francisco — Seattle — St. Louis — Tulsa — Washington. RESIDENT REPRESENTATIVES: Albany — Atlanta — Baltimore — Charlotte — Corpus Christi — Richmond, Va. — Shreveport. Crouse-Hinds Company of Canada, Ltd., Toronto, Ont.

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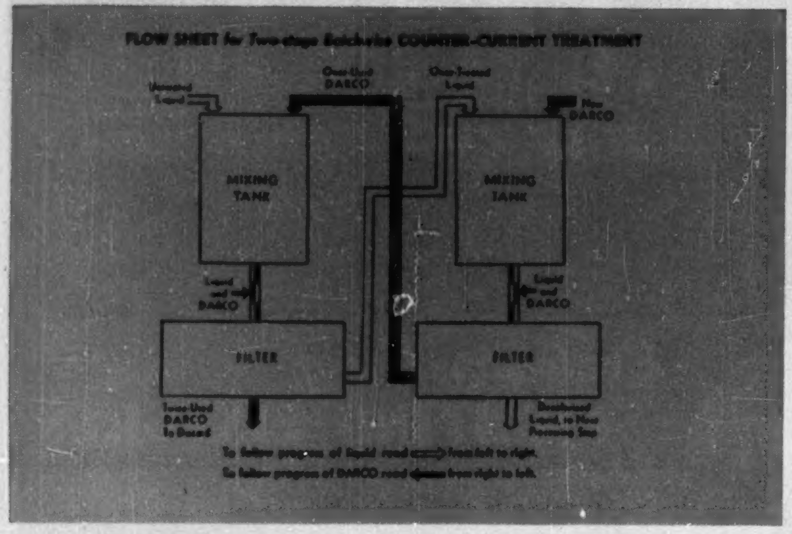
DARCO *Digest*

DARCO DEPARTMENT • ATLAS POWDER COMPANY
Darco General Sales Offices—60 EAST 42nd STREET, NEW YORK 17, N. Y.
ATLAS POWDER COMPANY, CANADA, LTD., BRANTFORD, CANADA

COUNTER-CURRENT TREATMENT WITH DARCO SAVES CARBON . . . PURIFIES BETTER



When a solution is decolorized or otherwise purified by means of activated carbon, the counter-current method often proves the most effective and economical way to do the job. Perfected by Darco technicians, this method performs the treatment in two steps instead of one. Initial treatment is made with Darco that has been used once, and final treatment with new Darco. The counter-current name comes from the fact that Darco moves through the process in the direction opposite to the liquor.

The principal advantage of counter-current treatment is savings in carbon. In comparison with one-step treatment, this method uses up to 40 per cent less Darco to produce the same amount of purification. When retention loss is an important economic factor, the lower carbon dosage results in further savings through lower loss of product in the filter cake.

The reason for the lower dosage is this: the fresh Darco first does the more difficult job of adsorbing the last traces of impurity, where its full adsorptive capacity is most needed. After doing this, the Darco still has ample capacity for the higher impurity concentration in the untreated liquor.

While a third step of counter-current treatment would effect further economies in carbon, two steps usually give the best overall economy of equipment. For further details, write for a copy of "Handbook for Counter-Current Treatment With Activated Carbon."

Why particle size is important

The size of particles of activated carbon requires accurate control, in order to arrive at the proper balance between filterability and adsorptive capacity.

As particle size becomes smaller, adsorptive capacity increases because the effective area is made larger. Filterability, however, drops off as the particles become small, due to their tendency to clog tightly in the filter.

Strict specifications on particle size of Darco assure you of the best compromise between these opposing factors. The carbon is ground so that substantially 100% passes a 100-mesh sieve, and about 70% passes a 325-mesh sieve. The correct distribution of particle size provides best overall results.

Send full details when requesting recommendations on using DARCO

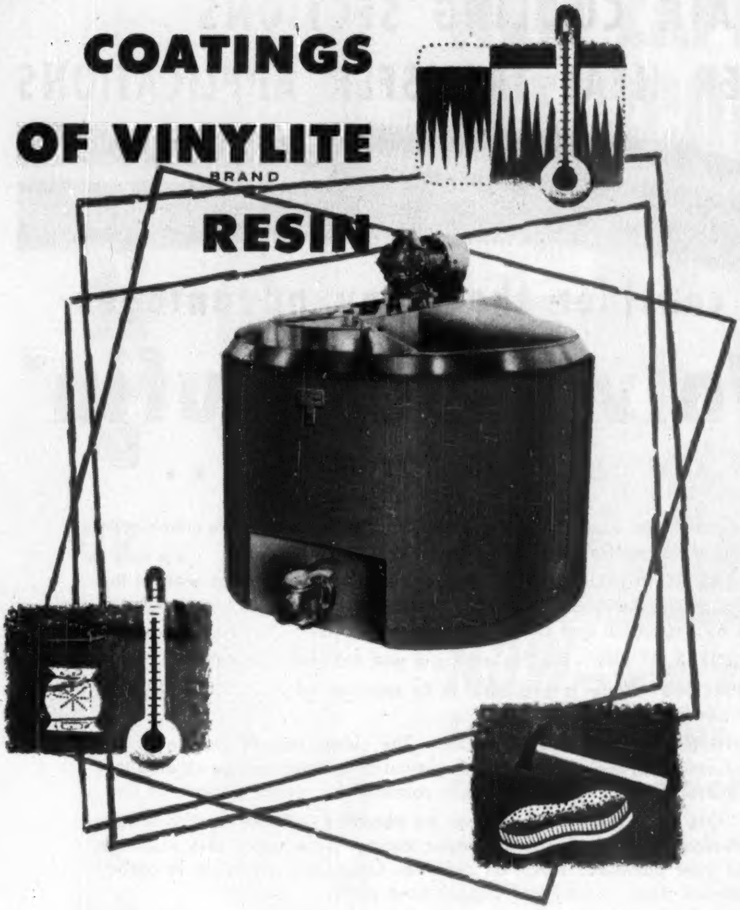
Darco specialists are always glad to assist you in finding the best grade of Darco for your application, the correct dosage, and most effective methods of use. The more you tell us about your own problem, the more specific will be our recommendations. Here's what we'd like to know in order to be able to help you:

Is the liquor you plan to treat aqueous or organic . . . liquid or solid at room temperature . . . affected by heating? What is its pH, viscosity, boiling point?

What is the impurity you wish to remove, and what is its concentration?

Is your application decolorizing, deodorizing, or general purification?

COATINGS OF VINYLITE BRAND RESIN



with the give that can take it!

Flexibility is a must when formulating coatings for milk processors and other equipment subject to rapid heating and quick cooling.

Such frequent wide temperature changes are rough on ordinary paints. However, coatings based on Vinylite Brand Resins just move with the metal, expanding and contracting the amount needed . . . adhering tenaciously.

Moreover, they are highly wear-resistant, and can take the constant washing and scrubbing required in food plants, and the scuffs and bumps of people, tools and equipment. Vinylite Resin coatings are highly chemical-resistant... unaffected by most detergents, chlorine solutions, acids and alkalies. And, they can be colored to practically any shade or deep tone desired for product identification or equipment coding.

No matter what you coat—dairy equipment, tank cars, oil refineries, marine installations, chemical plants—Vinylite Resin coatings bring outstanding results wherever surfaces are exposed to rough treatment, chemicals, salt water, industrial gases. Properly applied, they stay put on metal, concrete, masonry without cracking, chipping, peeling or fading.

You can improve performance as well as cut costs by using coatings based on one of the many Bakelite or Vinylite Resins. Write Dept. QF-46 for folder giving case histories of severe coating applications.

Photo shows milk plant equipment made by Cherry-Burrell Corporation, Chicago 6, Ill., and coated with Vinylite Resin coatings in Cherry-Burrell Blue. Coatings were prepared by Stoner-Mudge, Inc., Pittsburgh 33, Pa.

Case Histories Prove Performance

Bakelite Resin Floor Varnish—Floor finishes based on Bakelite Resins provide extreme wear resistance that minimizes maintenance costs. A typical case history has been the gymnasium floor of the Sewickley (Pa.) High School—subject to rough daily service from basketball and other events—even school dances. Yet, four years after being coated with an air-drying varnish based on Bakelite Resin, it still maintained its lustrous surface. No touch-up had been needed, either. And, the stripes and markings applied before the Bakelite Resin coating were just as sharp and new-looking as when applied.

Special-purpose Industrial Coatings—*Very few industrial coating problems are identical. Minute changes in formulations can make a tremendous difference in satisfaction. Coatings for water purification units are an excellent example. Here, a specially-formulated Bakelite Resin baking system provided not only the protection normally required for metal equipment, but also protected pipes and tanks against electrical leakage and the corrosive action of ozone.*

Vinylite Resin Coatings for Railway Equipment—Normal service conditions are tough enough on industrial coatings! Add the problems that railroad freight cars bring... vibration, weather variations, pounding with sledge hammers to loosen loads... and it takes top performance for a coating to stand up. Despite this rough and tough treatment, freight cars of the Illinois Central Railroad, protected with Vinylite Resin coatings, took this treatment plus rain, heat, cold, sun, corrosive loads and fumes for *over six years*—and the coatings were *still in good condition!*

Structural Finishes for Corrosion-Erosion Resistance—*Another example of how well Bakelite Resins solve difficult coating problems was the painting of structural steel work on river locks and dams in the Monongahela River. Acid pollution and flow of silt had developed a serious combination of costly corrosion and erosion. Reports stated "ordinary paints are of little value in preventing corrosion and erosion under the conditions described." After seven years' research and testing, the engineers in charge determined that pigmented Bakelite phenolic resin coatings were superior to any other for this use.*

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AND **Vinylite** BRAND
RESINS

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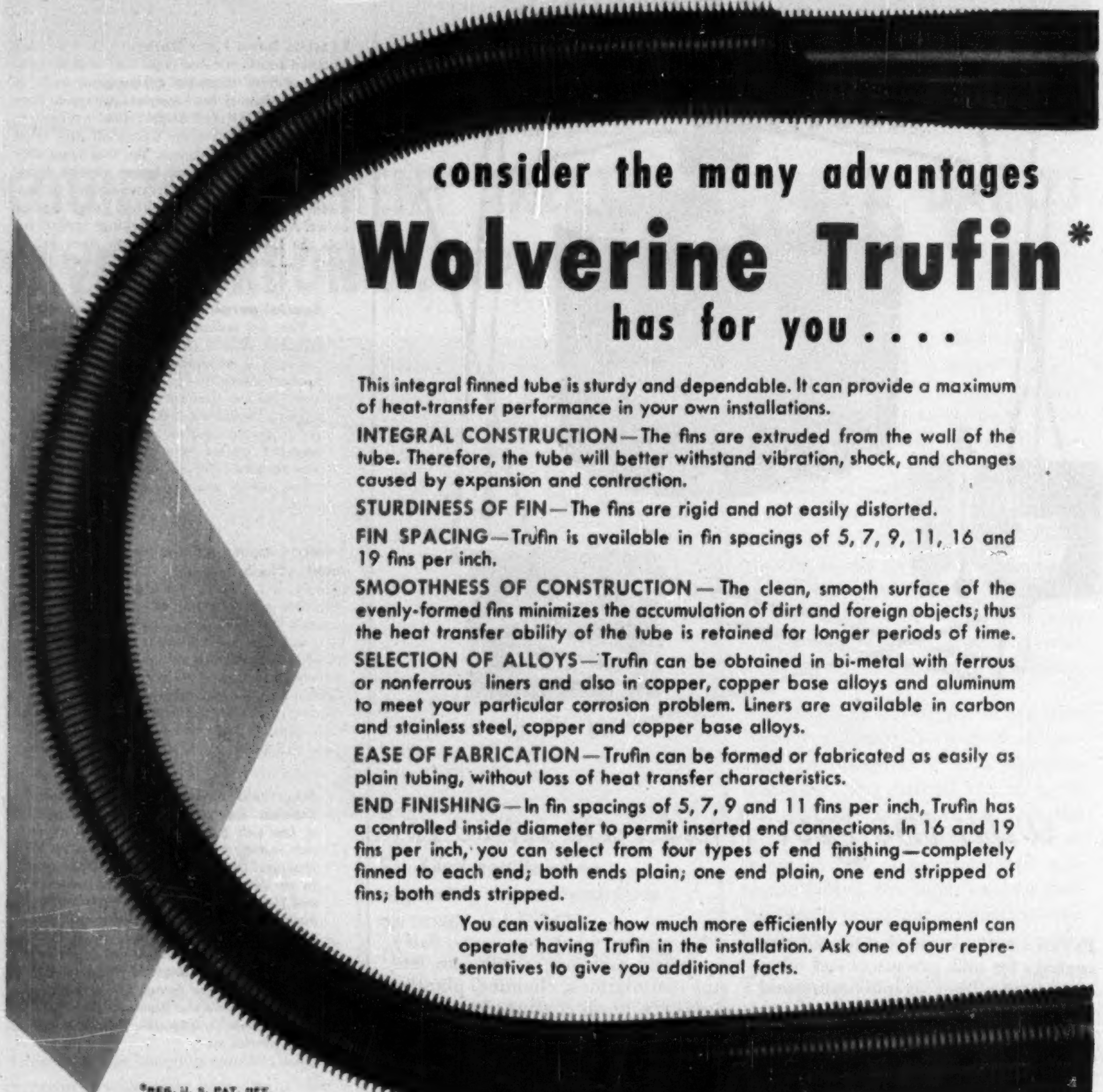

consider the many advantages

Wolverine Trufin*

has for you . . . .

This integral finned tube is sturdy and dependable. It can provide a maximum of heat-transfer performance in your own installations.

INTEGRAL CONSTRUCTION—The fins are extruded from the wall of the tube. Therefore, the tube will better withstand vibration, shock, and changes caused by expansion and contraction.

STURDINESS OF FIN—The fins are rigid and not easily distorted.

FIN SPACING—Trufin is available in fin spacings of 5, 7, 9, 11, 16 and 19 fins per inch.

SMOOTHNESS OF CONSTRUCTION—The clean, smooth surface of the evenly-formed fins minimizes the accumulation of dirt and foreign objects; thus the heat transfer ability of the tube is retained for longer periods of time.

SELECTION OF ALLOYS—Trufin can be obtained in bi-metal with ferrous or nonferrous liners and also in copper, copper base alloys and aluminum to meet your particular corrosion problem. Liners are available in carbon and stainless steel, copper and copper base alloys.

EASE OF FABRICATION—Trufin can be formed or fabricated as easily as plain tubing, without loss of heat transfer characteristics.

END FINISHING—In fin spacings of 5, 7, 9 and 11 fins per inch, Trufin has a controlled inside diameter to permit inserted end connections. In 16 and 19 fins per inch, you can select from four types of end finishing—completely finned to each end; both ends plain; one end plain, one end stripped of fins; both ends stripped.

You can visualize how much more efficiently your equipment can operate having Trufin in the installation. Ask one of our representatives to give you additional facts.

*REG. U. S. PAT. OFF.

Wolverine Trufin and the Wolverine Spun End Process available in Canada through the Unifin Tube Co., London, Ontario.

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• *The components of the Executone equipment used in hazardous areas are listed by Underwriters' Laboratories for Class I, Groups C and D or Class II, Groups E, F and G hazardous areas, as the case may be. The other Executone equipment is, of course, U. L. listed for use in safe areas.*

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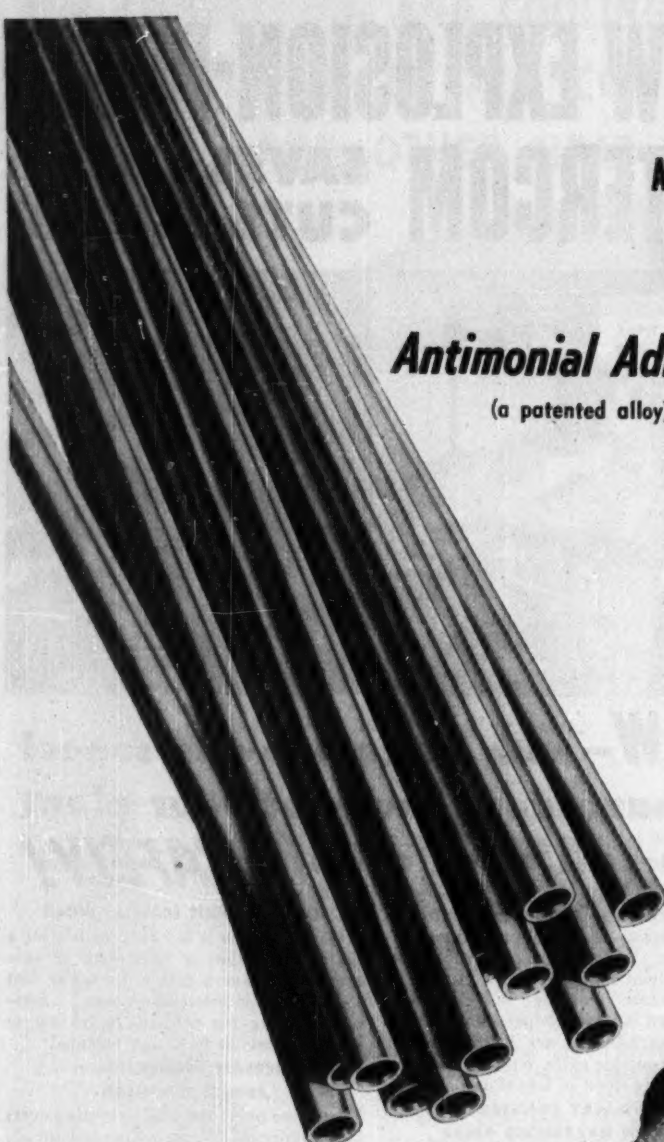

Yes, you can *count* on Chase Antimonial Admiralty Heat Exchanger Tubes to give you many years of satisfactory service.

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*U.S. Pat. No. 2,061,921

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WHEN GERONIMO WAS ON THE WARPATH

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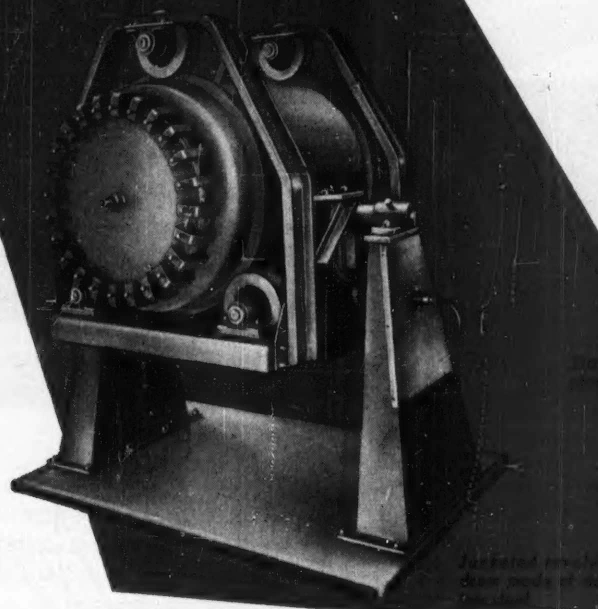
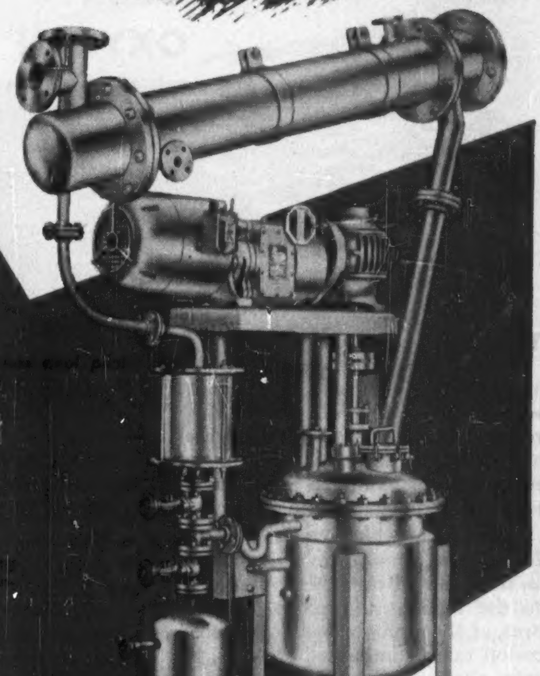
WAS MAKING INDIVIDUALIZED CHEMICAL EQUIPMENT





Even when the redman was on the warpath, KOVEN was part of the American scene. Then, KOVEN was clearing a new path for industry by creating Individualized Equipment tailored to the specific needs of manufacturers. For over 70 years, now, this path has been wide open to manufacturers with complex production problems. Let us show you how KOVEN Individualized Equipment can help you increase your output as you decrease costs. Call or write for a consultation. No obligation.

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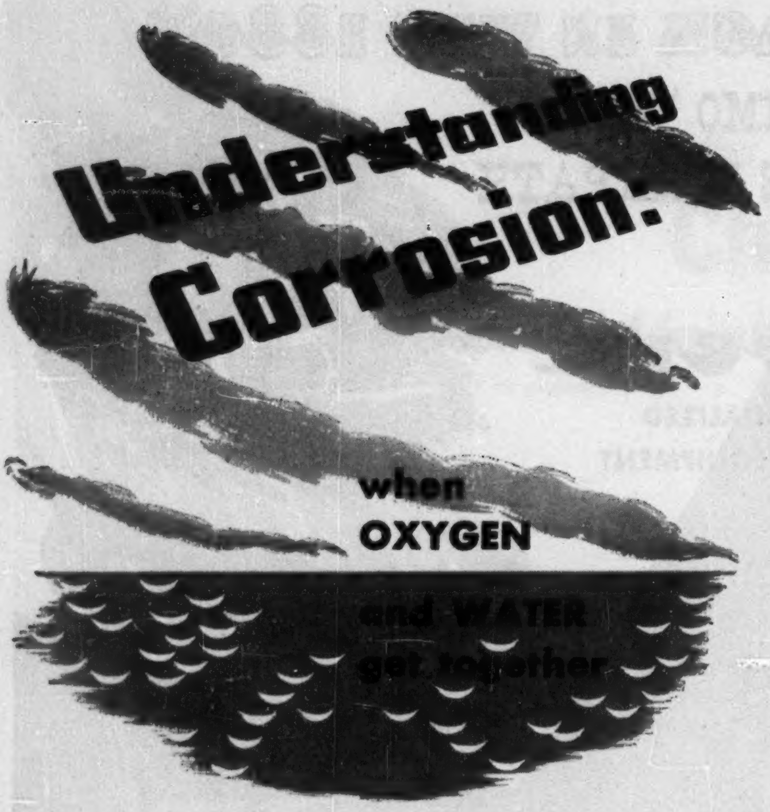

When free oxygen combines with atmospheric moisture or natural waters, the stage is well set for corrosive action. Controlling the degree and extent of that action are many related factors, variable in influence under differing circumstances.

The rate at which oxygen is transferred from atmosphere to a solution is, for example, directly proportional to the amount of exposed surface area of that solution, while the corrosion rate of immersed metal is, in turn, proportional to the oxygen concentration of the solution. Therefore, with all other factors stabilized, a reduction in exposed surface area will slow the oxygen-solution process, thereby greatly retarding corrosion.

How deeply metal is immersed, particularly in a quiet solution, is another determinant of corrosive action in which dissolved oxygen is the governing factor. Oxygen saturation, highest at and near the surface, diminishes with increasing depth as convection currents become less active. Corrosion at and immediately below the surface of a liquid is therefore far more severe than that encountered at greater depths.

These and other variables that combine to produce a given corrosion problem must be evaluated in any attempt to reach an effective and practical solution. Such evaluation, based on thirty-five years' corrosion-control experience, is standard Dampney procedure. That is why your specification of a Dampney Coating assures you so much *more* — protection you can depend upon to meet not only standard industrial service requirements but your specific equipment-operating needs. For data on Dampney Protective Coatings and their place in your corrosion-control program, write

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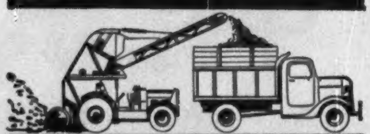

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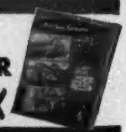

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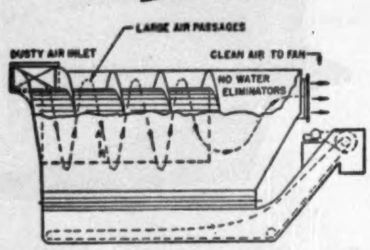

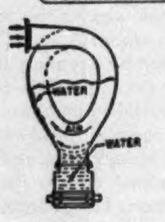

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When you need advice, help and emergency supplies of amazing Haveg cement, call your nearest district office. A Haveg sales engineer knows how to help you fight corrosion all the way. Ask to see his photo book showing the wide variety of Haveg molds and the machining possibilities of the material. WRITE TODAY for 64-page technical bulletin F-6. It gives complete information about Haveg, the material and the company that can help you solve your corrosion problems.

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20,000 p.s.i. high frequency pressure cell. Length-5½", diameter 2", weight-1 #

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1. **High Accuracy**—pressure versus voltage outputs are linear with ¼ of 1% and calibration (span) is held within ½ of 1%.
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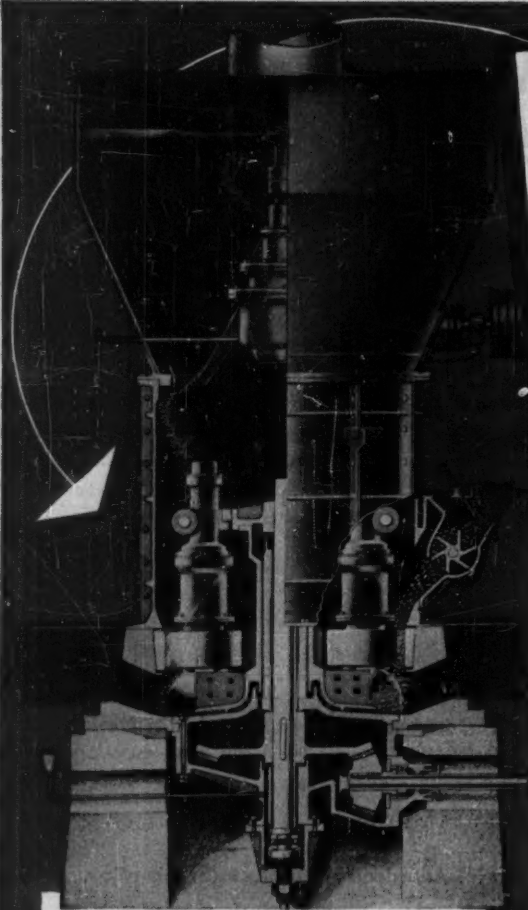

Cross section of Roller Mill showing how material is ground by rolls rotating against bull ring, then air swept to separator which extracts fines and returns coarse material to mill for regrinding.

WILLIAMS *Roller Mills*

Insecticide formulas, pigments and dry colors, barytes, phosphate, limestone—whatever the material, if it has to be finely ground, there's a Williams Roller Mill to do it—faster, for stepped up production—more accurately and uniformly—and at far less cost!

Automatic and continuous in operation, the Williams also dries and grinds simultaneously. Instantly adjustable for finenesses of 20 to 400 mesh, even down to micron sizes. No built-up cushions of "fines" can impair grinding efficiency because the constant upward air current carries ground materials to the air separator which discharges *all* finished materials and returns *only* the oversize product to the mill for further grinding.

Feeding rate is automatic and self-adjusting, positive and simple in action—Anti-friction roller and ball bearings reduce down-time for lubrication, save oil and put more power into grinding—Take-up for wear is continuous and automatic—Rugged forgings, electric steel and alloy castings guard against wear and breakdowns—These and many other outstanding features have made Williams Roller Mills the standard for fine-grinding operations.

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Heavy duty construction in many sizes for crushing and grinding to small size, in one operation, phosphate, gypsum, limestone, shale, bauxite, asbestos rock and virtually all other chemical and fibrous materials.

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Dust-free fine grinding, 100 to 325 mesh, without fans, cyclones or air separators. Variable speed feed control. Will also handle wet, sticky, oily and greasy materials without clogging. Easy to install; inexpensive to operate.

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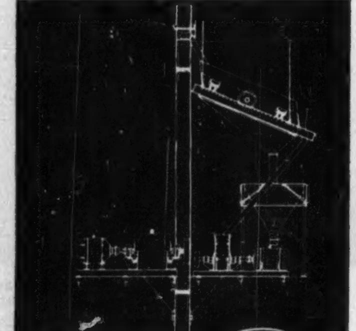
Backed by years of know-how and experience, Williams can build any type of ready-to-install plant to handle crushing, grinding, air separation, sifting, conveying and magnetic separation including storage bins and electrical equipment.



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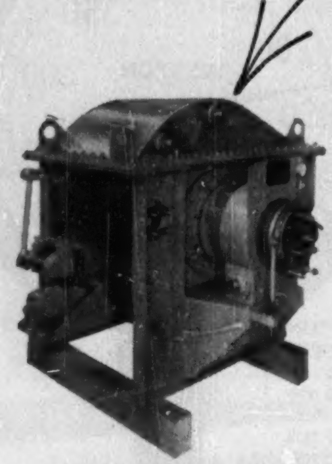
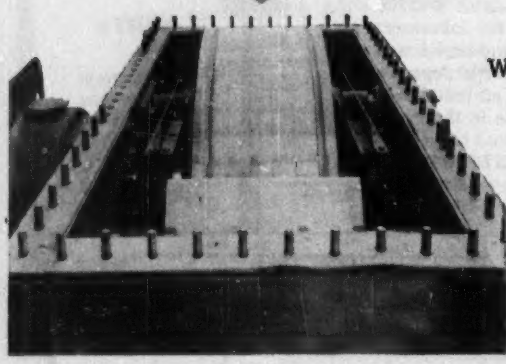
A COMBINATION OF CORROSION PROBLEMS

—all solved with *Carpenter* materials

sulphuric acid, nitric acid and potassium permanganate safely handled by Stainless #20



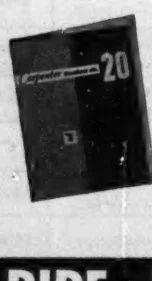


The materials handled by this continuous vacuum filter are not only corrosive but toxic. The principal corrodent in the filtrate is sulphuric acid (PH1). The solutions used for periodic cleaning of the filter are nitric acid and potassium permanganate.

To withstand this combined attack, all parts of the filter that come in contact with slurry, cake or filtrate are made from Carpenter Stainless #20—sheet, pipe, nipples, electrodes, rounds, etc. The hood to contain the gases is made from Carpenter stainless sheet, type 316.

Wherever corrosion is a problem, it will pay you to get in touch with your nearby Carpenter Distributor. He can put at your disposal our 25 years of experience in providing materials to withstand corrosion and the necessary "know-how" to fabricate them easily. The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

Export Dept.: The Carpenter Steel Co., Port Washington, N.Y. "CARSTEELCO"



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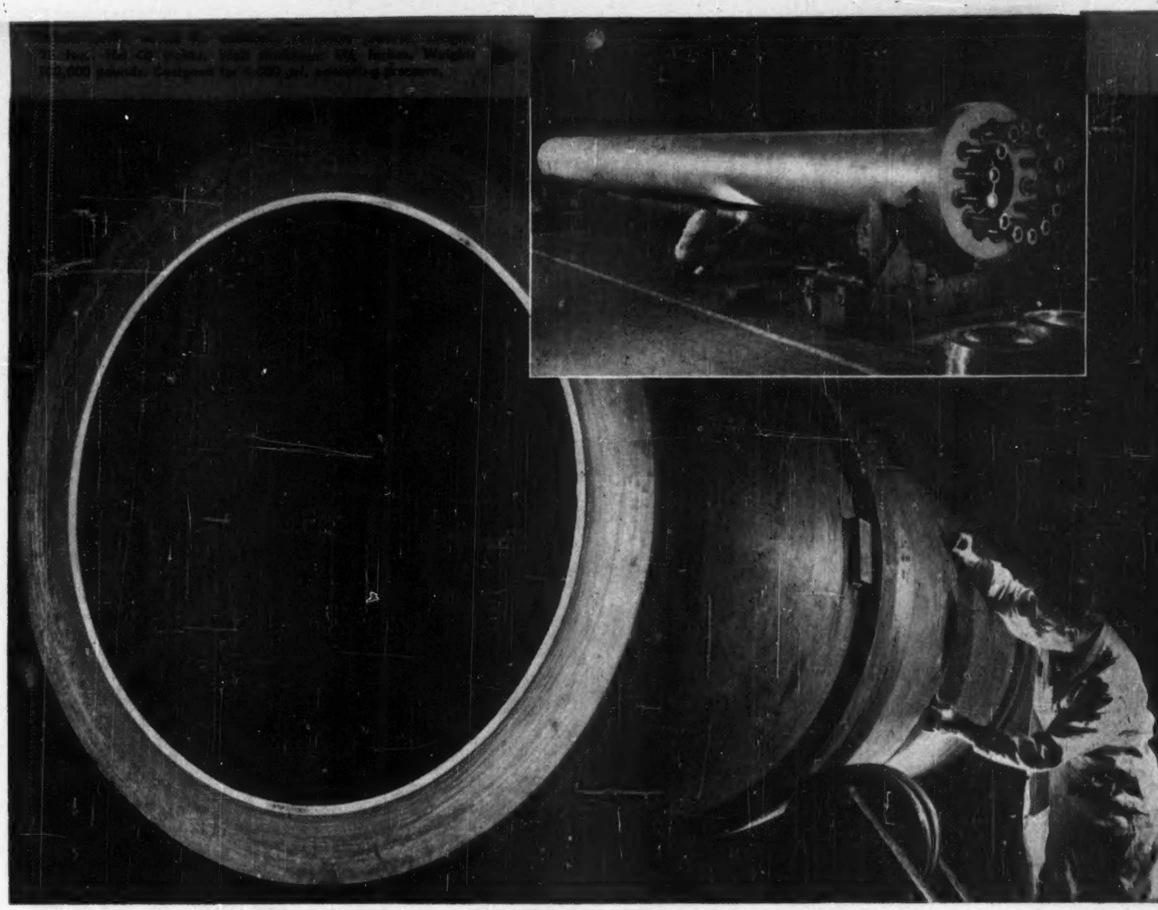

One of the shell courses for this multi-layer vessel. The end view shows the ½" thick inner cylinder of stainless steel, with the thinner steel plate wrappings around it scarfed for welding.

A. O. Smith MULTI-LAYER process gives chemical industry safe vessels for

Nitrogen Expansion Program

Many full scale vessels have been tested to destruction to prove the safety features of Multi-layer construction.

The high pressures of 4,000 to 15,000 psi, needed in the ammonia and urea synthesis process are completely met by the patented A. O. Smith multi-layer process.

As the name implies, multi-layer vessels are built up from concentric layers of relatively thin steel plates progressively wrapped, tightened and welded together around a pressure-tight cylinder. This means that vessel walls can be built up to the thickness demanded by the pressures required for the process. In the remote event of run-away overload, fragmentation of vessel walls is practically impossible due to the nature of multi-layer construction.

Automatically Vented—Only the inner cylinder of a multi-layer vessel need be pressure tight. The outer layers are provided with vent holes. In applications involving hydrogenation, venting prevents embrittling attack on the load-bearing layers.

Besides complete safety, you get these added features with multi-layer vessels.

BETTER DELIVERIES because multi-layer construction uses more readily obtainable thin steel plates.

CORROSION IS NO PROBLEM: Only the inner cylinder need be made of the specified alloy for the corrosion service. This saves expensive critical materials because the load bearing portion of the vessel wall—not in contact with corrodents—is manufactured of more economical steel plate.

NO SIZE OR WEIGHT LIMITATIONS. No compromises need be made in size or weight since restrictions imposed by ingot size or forming techniques do not apply to multi-layer construction.

WRITE TO
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PROCESS EQUIPMENT DIVISION
DEPT. CE 653
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A.O.Smith
CORPORATION
VESSELS • HEAT EXCHANGERS

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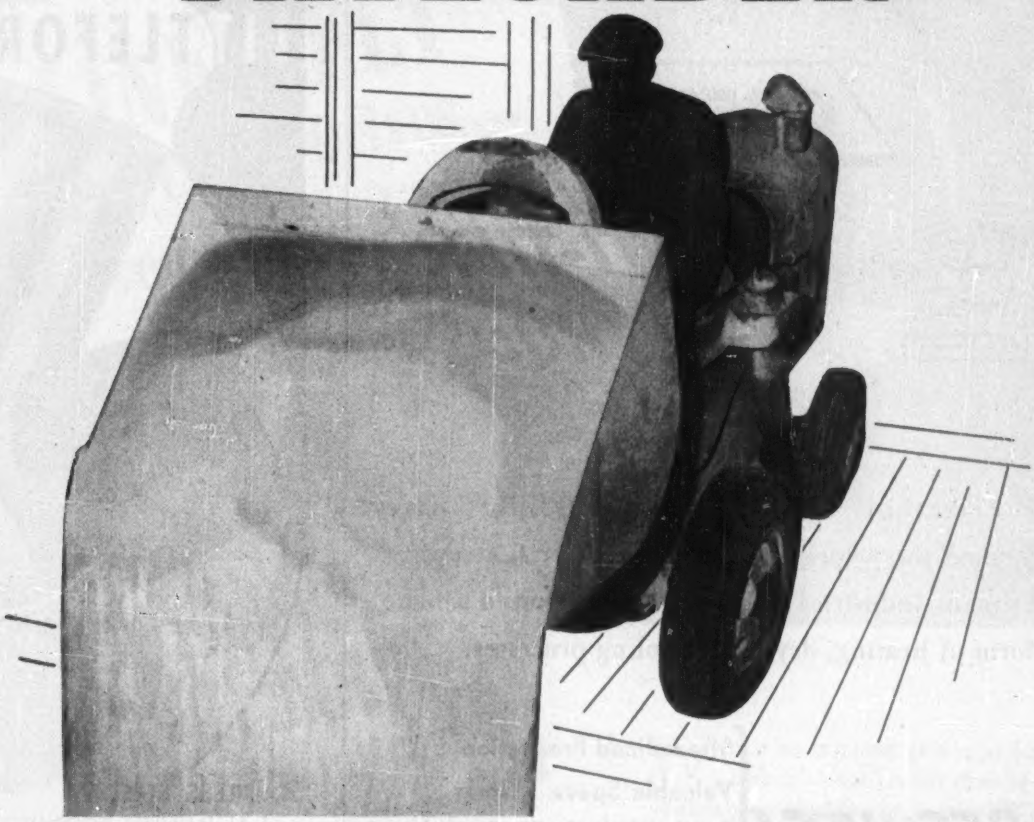
PAYLOADER

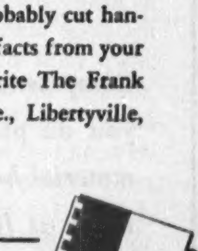


For Fast, Flexible **BULK-MATERIAL** *Handling!*

"PAYLOADERS" spell flexibility and low-cost in the handling of fertilizers, chemicals and other loose, bulk materials. And these tractor-shovels can go to work cutting handling costs *right away.* No expensive investment or plant rearrangement is required before you begin reaping "PAYLOADER" benefits. They travel swiftly indoors and out and maneuver in close quarters. They scoop-up, carry, load, dump, spread . . . lift and lower . . . push and pull. They load and unload boxcars of bulk. In fact, "PAYLOADERS" are being used for so many jobs in so many plants that they can probably cut handling costs for you too. Get all the facts from your "PAYLOADER" Distributor or write The Frank G. Hough Co., 754 Sunnyside Ave., Libertyville, Illinois.

FREE HANDBOOK

Tells how and where to look for signs of inefficient bulk-materials handling . . . how to analyze, organize and set up an efficient handling system. Plus many useful tables and data. Write for "Bulk Materials Handbook."



PAYLOADER

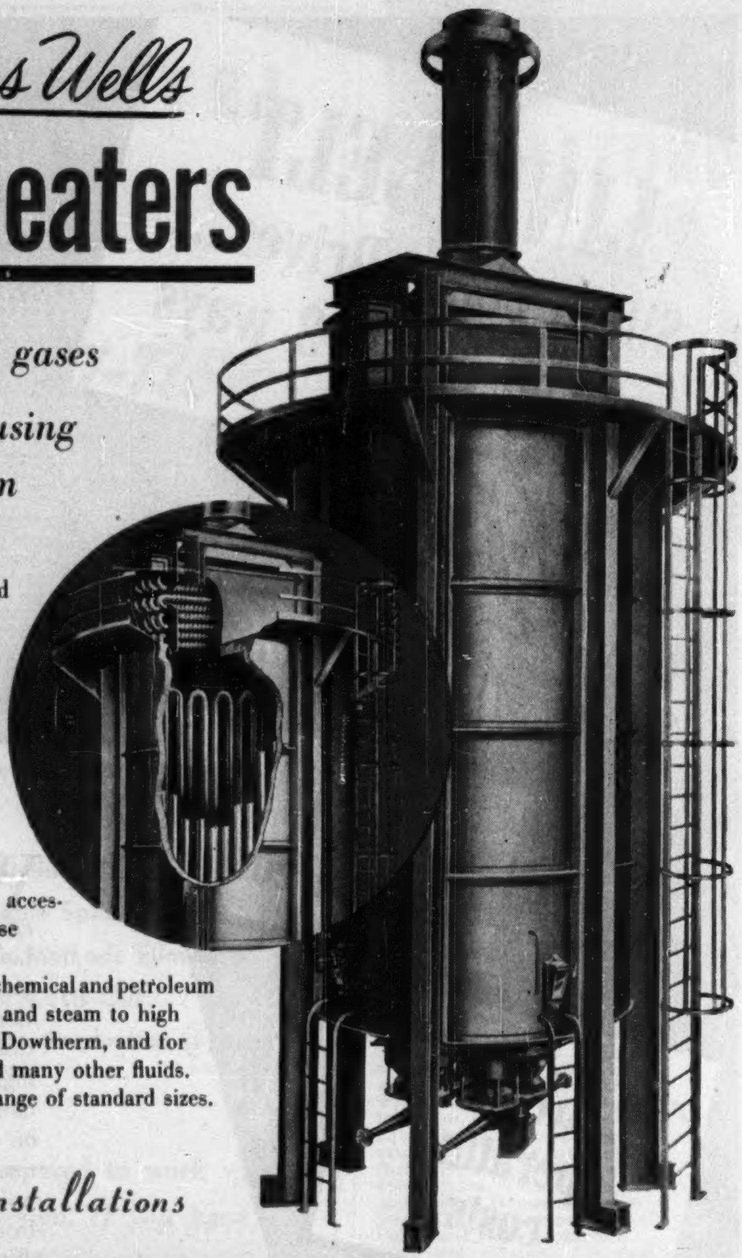

LINK-BELT
Silent Chain Drives...
proved better 3 ways
LOW
initial cost
LOW
operating
costs
HIGHER
motor speeds
WANT to transmit power at high speeds . . . *with better than 98% efficiency for the life of the drive?* With Link-Belt Silverstreak Silent Chain you get lower initial cost on many applications . . . lower operating costs in all cases. In addition, ability to operate at higher speeds means less investment in motors and controls. Efficient operation on extremely short centers saves space, too. Remember, you can get positive, no-slip Link-Belt Silent Chain Drives from fractional to thousands of hp, with drives from ½ to 50 hp available from stock. Ratios range from 1:1 to 7:1. Contact your nearby Link-Belt office or distributor today.
LINK-BELT
SILVERSTREAK SILENT CHAIN DRIVES
LINK-BELT COMPANY: Plants: Chicago, Indianapolis, Philadelphia, Colmar, Pa., Atlanta, Houston, Minneapolis, San Francisco, Los Angeles, Seattle, Toronto, Springs (South Africa), Sydney (Australia). Sales Offices, Factory Branch Stores and Distributors in Principal Cities.
13,241

Struthers Wells

Fired Heaters

For heating liquids and gases

For indirect heating using circulating medium



The Struthers Wells fired heater is designed to give efficient and trouble-free operation in a wide range of services.

Moderate rates of heat input, symmetrical arrangement of tubes, and the liberal heat absorption surface provided, eliminate overheating of the equipment or the heated fluid.

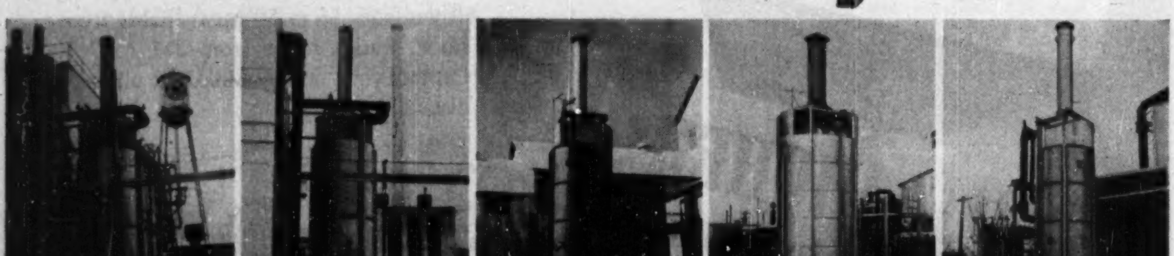
High thermal efficiencies are secured; the convection section surface is provided with heavy welded fins.

Equipment is provided with all necessary accessory and control equipment if required; close temperature control may be secured.

This equipment is being widely used in the chemical and petroleum industries for heating air, hydrocarbon gas and steam to high temperatures, for indirect heating utilizing Dowtherm, and for direct heating of absorption oil, asphalt and many other fluids.

Good deliveries are available in a wide range of standard sizes.

Typical Installations



Struthers Wells

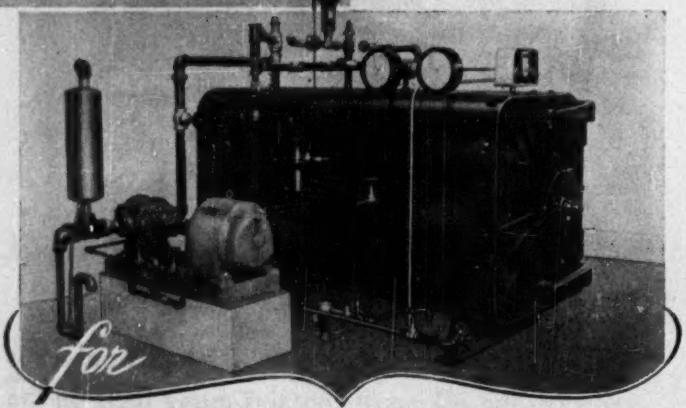
STRUTHERS WELLS CORPORATION

WARREN, PA.

Plants at Warren, Pa. • Titusville, Pa.

Offices in Principal Cities

American VACUUM-PRESSURE CHAMBERS



Steam Sterilization • Automatically controlled temperatures and exposure periods • Corrosion resistant metal chambers • Quick opening and closing "safety stop" door.

Carboxide Gas Sterilization • Positive sterilization of heat- and moisture-sensitive products at low temperatures: Plastic Containers • Packaged Pharmaceuticals • Surgical Dressings • Packaged Food Products • Rubber Goods.

Moisture Impregnation • Products may be increased in moisture content by economical constant temperature-constant humidity process • Temperatures may be controlled to achieve destruction of insects, larvae and eggs.

Pasteurization • Temperatures ranging from 150° to 250° F maintained uniformly throughout chamber. Settings easily changed to accommodate various products.

Fumigation • Vacuum-pressure chambers for use with carboxide, methyl bromide or other gases for fast-high production fumigation.

• Specialists and Consultants in Sterilization, Fumigation and Sanitation for the Pharmaceutical, Chemical and Food Processing Industries since 1894

For additional information write to Department IB-6.

AMERICAN STERILIZER COMPANY • Erie, Pennsylvania

Only 3 MOVING PARTS *in the* HENSZEY *Indicating* FLOW METER

Only three moving parts—the Pointer, the Lever Shaft and the Plunger. That means continuous service and CONSTANT ACCURACY.

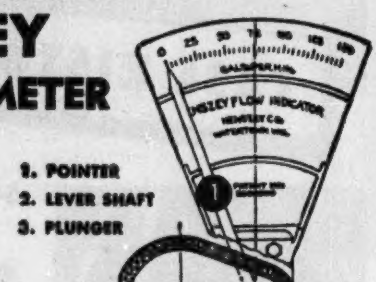
The liquid enters below the plunger, forcing it upward and exposing more area of the metering slots so that the motion is in direct proportion to the flow.

The graduations on the dial are uniformly spaced from one end to another and read direct—without constants. The meter is installed right in the pipe line.

For Details Consult Sweet's Catalog or Write

HENSZEY COMPANY
Dept. E-6, WATERTOWN, WISCONSIN

1. POINTER
2. LEVER SHAFT
3. PLUNGER



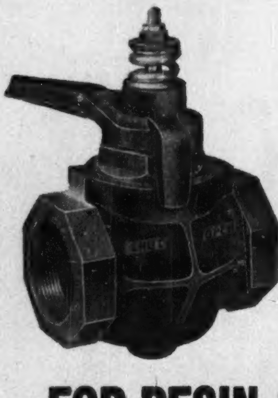
HENSZEY

Indicating FLOW METERS

Continuous Blowdown • Distillation System • Heat Exchangers
Feed Water Meters • Boiler Feed Regulators • Proportioning Valves
also MILK EVAPORATORS and PRE-HEATERS

DeZURIK VALVES

NON-GUMMING NON-LUBRICATED



. . . FOR RESIN & GLUE SERVICES

IT'S BEEN PROVED ON MANY JOBS DeZURIK PLUG VALVES will handle resinous chemicals with an absolute minimum of "Gum Up" or "Build Up." Their eccentric-plug construction keeps them operating without sticking, and their resilient plug-faces keep closing leak-tight despite tendencies in the flow to accumulate or obstruct closure.

DeZURIK VALVES are non-lubricated, yet open or close E-A-S-I-L-Y with a smooth quarter-turn. One trial installation will demonstrate that they handle resins, glues, latex and other materials with the least maintenance, cleaning or binding . . . and with NO leakage.

DeZURIK SHOWER CO.
SARTELL, MINN.

WeldELLS®

...have set their own standards

Many of the largest users of Welding fittings refuse to accept any other fittings than WeldELLS.

They have found that when the name, WeldELL, is stamped into a fitting, that fitting can be accepted without question for any service for which it is designed.

They have found that WeldELLS have features that please both the men who design and the men who erect welded piping . . . features that were pioneered by Taylor Forge . . . features that are combined in no other welding fittings.

They have found the answer to their every need in the greater range of sizes, weights and types of the WeldELL line . . . in the broader scope of materials.

Ask for up-to-the-minute facts about WeldELLS and Taylor Forged Steel Flanges.

TAYLOR FORGE

TAYLOR FORGE & PIPE WORKS, General Offices and Works: P.O. Box 485, Chicago 90, Ill.
Offices in all principal cities. Plants at: Carnegie, Pa.; Fontana, Calif.; Hamilton, Ont., Canada

BUFLOVAK

can help you solve processing problems— at a PROFIT

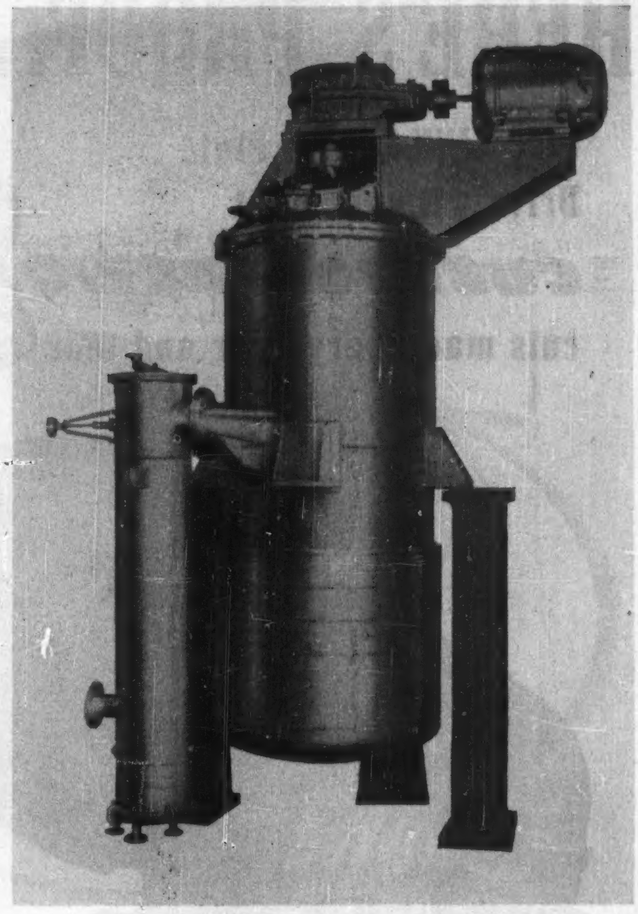
BUFLOVAK has helped another nationally-known manufacturer produce a better product at lower cost by combining two processes into one. That, of course, means greater profits!

A valuable, dilute, heat-sensitive solution is carried to high concentration in a single, compact unit. Ordinarily a two stage process would be required.

Special equipment was engineered for the job. A low-temperature, sanitary evaporator steamchest and a high vacuum processing kettle equipped with an agitator and selectable heating surfaces, were combined into a single, integral unit.

Through the combined facilities of our Research and Testing Laboratories, coupled with extensive field experience, BUFLOVAK Engineers design processing equipment for the most profitable results.

BUFLOVAK Catalogs have a wealth of valuable information on drying, evaporation and processing. A request on your company letterhead will bring copies to you.



A special BUFLOVAK Evaporator-Still which combines two processes into one.

BUFLOVAK Research and Testing Laboratory

To assist you in the solution of processing problems, BUFLOVAK offers the facilities of its Research and Testing Laboratory . . . where small scale experimental units show you, before you buy, the commercial possibilities, data on production costs, and characteristics of the finished product.

BUFLOVAK Processing Equipment

EVAPORATORS	DRYERS	PROCESSING KETTLES
Low-Temperature	Vacuum Double Drum	Mixers
By-Product Recovery	Vacuum Rotary	Impregnators
Chemicals	Pilot Plant	Dopp Kettles
Food Product	Atmospheric	Solvent Recovery & Distillation Equipment
Crystallization		

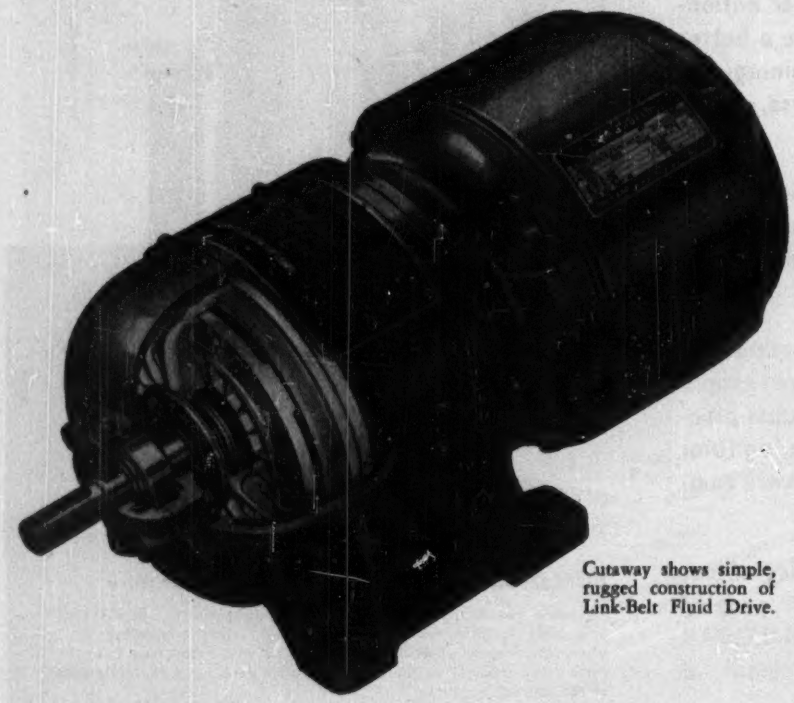
SEND FOR CATALOGS

BLAW-KNOX

BUFLOVAK EQUIPMENT DIVISION
1551 FILLMORE AVE.
BUFFALO 11, N.Y.

HERE'S PROOF...

that LINK-BELT's Fluid Drive with constant CUSHION ACTION cuts machinery wear and tear



Cutaway shows simple, rugged construction of Link-Belt Fluid Drive.

Now you can use smaller motors and power transmission equipment on your toughest drive problems. What's more, both motors and driven machines will last longer with Link-Belt Fluid Drives.

That's because constant CUSHION ACTION provides shock and overload protection . . . and at the same time eliminates high starting torque requirements and high starting currents.

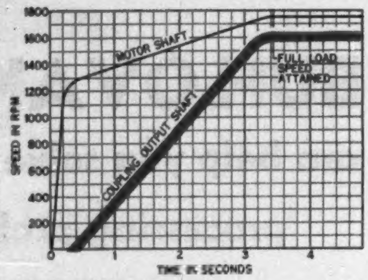
Look at the three sets of curves shown here. See for yourself how constant CUSHION ACTION is the money-saving answer for loads of the high inertia, repetitive shock or high starting torque type.

For complete information, write for Book 2485. It shows how you can put five types of Link-Belt Fluid Drives to work in your plant: Electrofluid Drive, Electrofluid Gearmotor, Fluid Drive, Fluid Gear Drive and Fluid Coupling Drive.

13,003

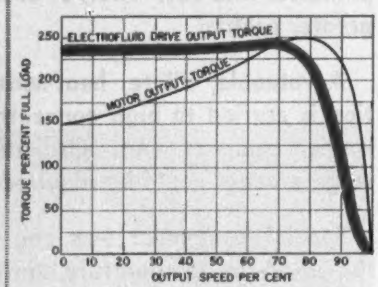
LINK-BELT
FLUID DRIVES

Smooth acceleration - -



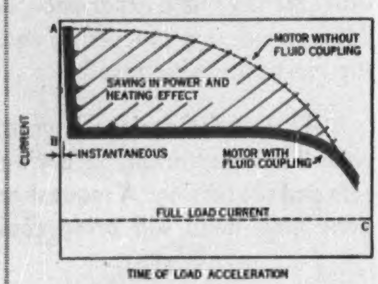
Typical motor and coupling acceleration curves for a high-inertia load show how CUSHION ACTION smoothly and gradually accelerates the load, saving wear and tear on vital equipment.

No overpowering - -



Compare the output torque of a motor with and without the fluid coupling. Because motor accelerates free of load, it reaches maximum pull-out torque that might otherwise require a special type of oversize motor.

Low starting current - -

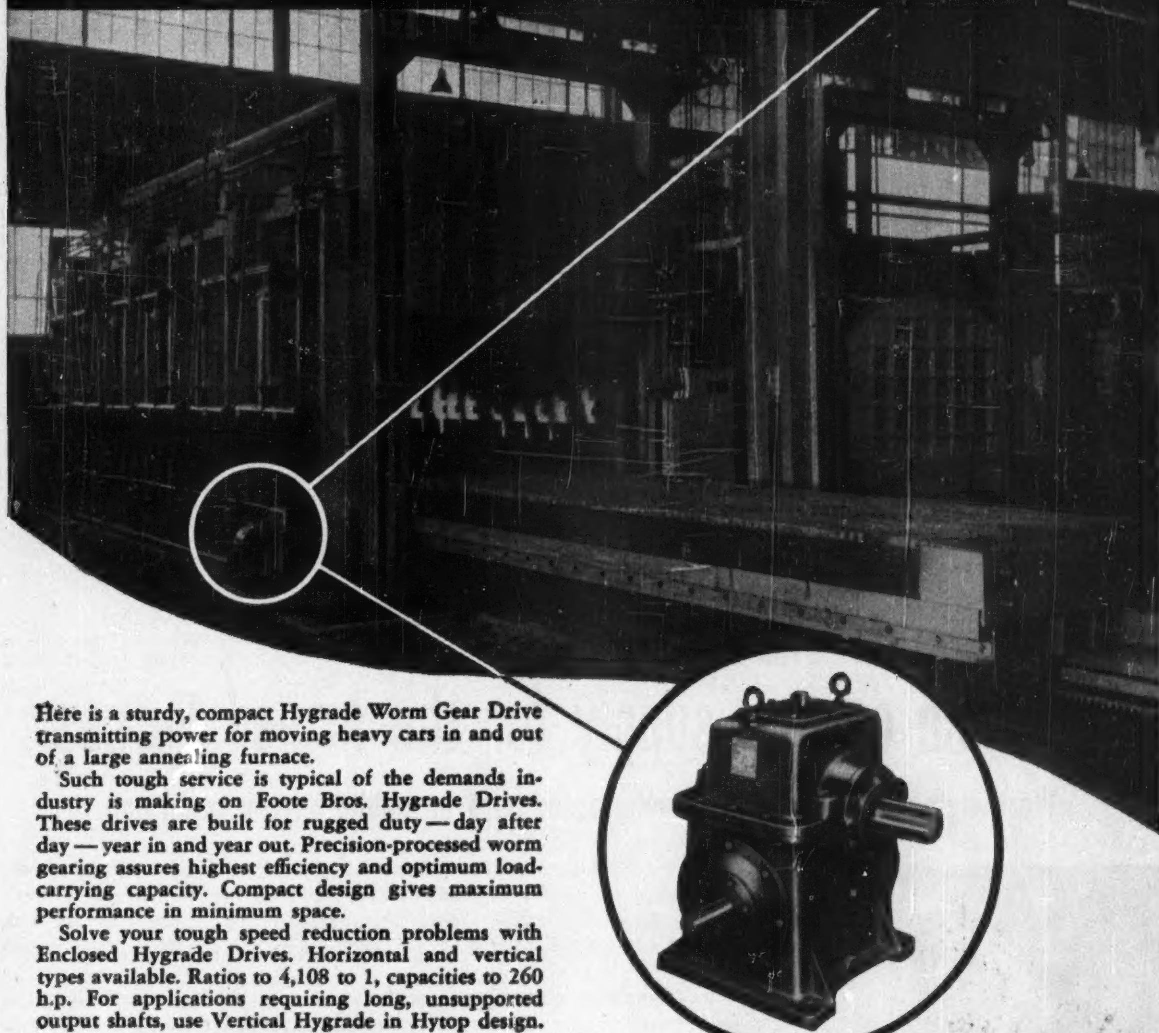


As these current consumption curves show, with the fluid coupling, motor starting current drops instantaneously to less than half the starting current required by a motor without fluid coupling. Difference represents power savings, reduced heating.

LINK-BELT COMPANY: Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8, Springs (South Africa). Offices, Factory Branch Stores and Distributors in Principal Cities.

FOR RUGGED DESIGN
TROUBLE-FREE OPERATION . . .

Choose HYGRADE DRIVES!



Here is a sturdy, compact Hygrade Worm Gear Drive transmitting power for moving heavy cars in and out of a large annealing furnace.

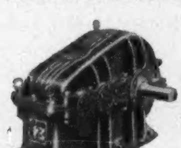
Such tough service is typical of the demands industry is making on Foote Bros. Hygrade Drives. These drives are built for rugged duty—day after day—year in and year out. Precision-processed worm gearing assures highest efficiency and optimum load-carrying capacity. Compact design gives maximum performance in minimum space.

Solve your tough speed reduction problems with Enclosed Hygrade Drives. Horizontal and vertical types available. Ratios to 4,108 to 1, capacities to 260 h.p. For applications requiring long, unsupported output shafts, use Vertical Hygrade in Hytop design.

See your Foote Bros. representative or write for information

One of 15 car-type furnaces using Hygrade Drives at Warren, Ohio, plant of Copperweld Steel Company. Installed by Pennsylvania Industrial Engineers Division, Amsler Morton Co.

LINE-O-POWER DRIVES



MAXI-POWER DRIVES

FOOTE BROS.-LOUIS ALLIS GEARMOTORS

FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS.
GEAR AND MACHINE CORPORATION
Dept.CE, 4545 South Western Boulevard
Chicago 9, Illinois

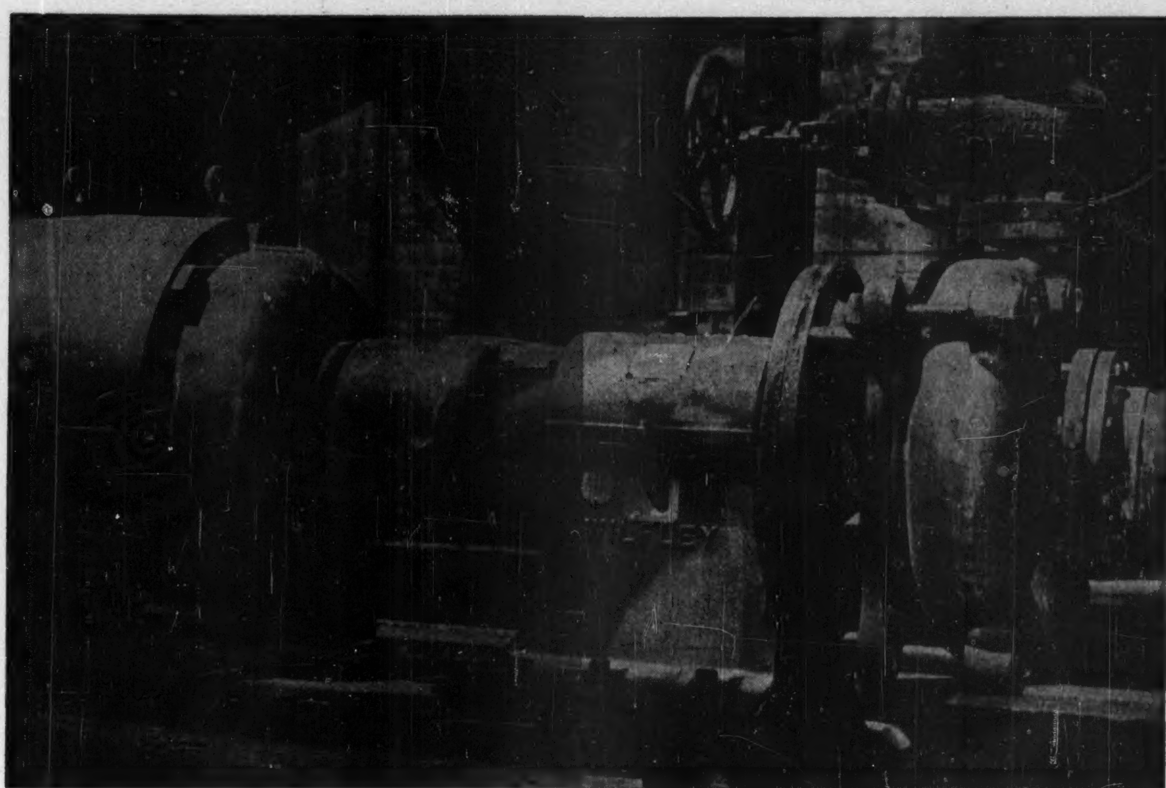
Please send me a free copy of Bulletin HGB on Foote Bros. Hygrade Worm Gear Drives.

Name...

Company...

Address...

City.......................................Zone..............State.......................



How Layne assures your water supply

UNDIVIDED LAYNE RESPONSIBILITY MEANS COMPLETE SERVICE, LOWER COSTS

Layne surveys and test wells

Layne's *complete* service begins long before the wells are drilled . . . with geological surveys made in cooperation with engineers of the client company or municipality. Test-hole drilling shows actual conditions.

Layne analyses and recommendations

Samples taken from the test holes go to Layne's central laboratories, where technicians report on the earth structure and qualities of the water. From these reports, water-system recommendations are made.

Layne-engineered pumps, screens, casings

Into every Layne well goes equipment designed for the specific job—the finest equipment, produced with the greatest economy, because of Layne's thorough engineering skill and world-wide experience.

Layne installation and maintenance service

Skilled Layne workmen handle every stage of the job—assuring a system custom-engineered for your own situation. And Layne's experience is always at your service for any maintenance work you may need.

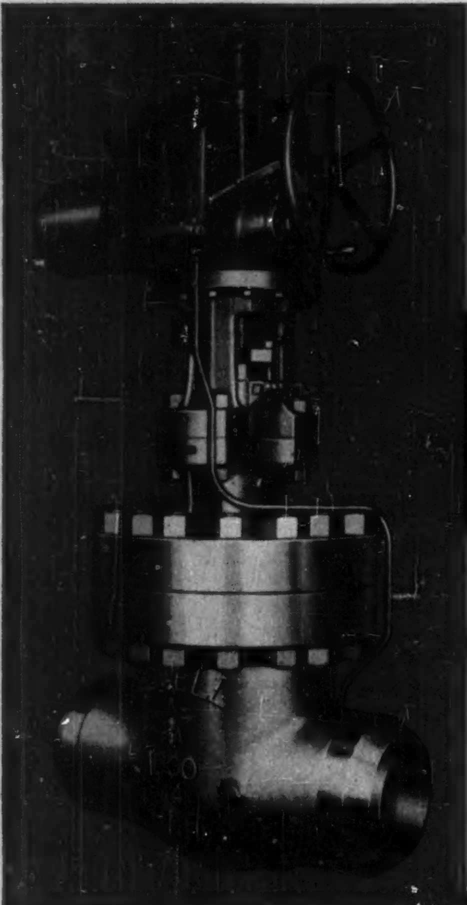
Let Layne help you plan ahead on your water needs

Layne welcomes the opportunity to share in long-range planning for your water-supply needs. For information on any phase of well water supply or pump equipment, contact your nearest Layne Associate Company or write Layne & Bowler, Inc., General Offices, Memphis 8, Tenn.

Layne

WATER WELLS • VERTICAL TURBINE PUMPS
WATER TREATMENT

Layne Associate Companies Throughout the World



With

LIMITORQUE REMOTE CONTROL

One man can operate any number of Valves, at any distance, from a push button station centrally located.

A Philadelphia Engineer will gladly call and help you with your valve operating problems. Write us now.

Limitorque makes possible the centralized operation of valves in remote or hazardous locations from convenient and strategically placed control panels. Thus, this vital plant operating procedure can be handled by key employees, and is not dependent upon brawn alone.

Limitorque opens and closes any type of valve quickly and dependably. Valve stems, seats, discs, plugs and gates are fully protected from damage during closing cycle by the torque limiting mechanism. There are *many* exclusive design and construction features in Limitorque Controls, which are reasons for the world-wide preference for these "proved" Valve Operators.

Philadelphia Gear Works, INC.

ERIE AVE. AND G ST., PHILADELPHIA 34, PA.

NEW YORK · PITTSBURGH · CHICAGO · HOUSTON · LYNCHBURG, VA.

Industrial Gears and Speed Reducers
LimiTorque Valve Controls

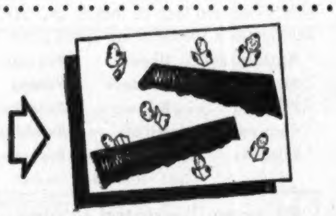
All business is specialized

...and nothing specializes on <u>your</u> business like your business paper

This smart business man spends his time where every sitzmark parks a prospect at his feet. He *specializes.* Your business is specialized, too... and so is your business paper. It's concentrated on *your* business. Both editorial and ad pages report what's new that's good... suggest new methods... gather in one place a raft of ideas on where-to-buy-what.

That's help you can't find concentrated into such quick reading time anywhere else! It's simple sense to read every page... every issue.

This business paper in your hand has a plus for you, because it's a member of the Associated Business Publications. It's a *paid* circulation paper that must *earn* its readership by its quality... And it's one of a leadership group of business papers that work together to add new values, new usefulness, new ways to make the time you give to your business paper still more profitable time.



A copy of this quick-reading, 8-page booklet is yours for the asking. It contains many facts on the benefits derived from your business paper and tips on how to read more profitably. Write for the "WHY and HOW booklet." Room 2710.

McGRAW-HILL PUBLISHING COMPANY
330 W. 42nd St., New York 36, N. Y.

One of a series of ads prepared by THE ASSOCIATED BUSINESS PUBLICATIONS

LECITE · EL CHEM

Two important names to remember when you plan chemical construction!

LECITE — a synthetic resin cement, combines the most desirable properties of the phenolics — and eliminates their disadvantages.

Alkali-proof, as well as acid-proof, LECITE has a wide diversity of applications. It serves as

- Bonding agent
- Impervious liner, when reinforced with glass cloth or metal mesh
- Mortar for corrosion-proof brick lining
- Impervious membrane between brick or tile floor and concrete sub-base

LECITE is *inert to all acids*, except a few strongly oxidizing chemicals, and to all alkalis of all concentrations; also to most organic solvents and to oils and greases.

LECITE *has a tensile strength of 1,000 psi.*, adheres to brick and other ceramic surfaces with a bond of over 700 psi.; and it withstands temperatures up to 370° F.

LECITE *may be stored indefinitely*; has longer working time without sacrifice of final setting speed; will set under damp conditions and at temperatures as low as 45° F.; is available in compositions having high or low electrical restivity and it has high impact resistance.

LECITE is widely used in the equipment of plants producing organic chemicals, phenol, alcohol, nylon, copper sulphate, acids, textiles, steel, soft drinks, soaps, food and dairy products. It serves in reactors, filters, towers, alkylators, neutralizing tanks, stacks and fume ducts.

Nutsch Filters — Used to filter hot mixtures of sulphuric acid and organic materials. Welded steel construction, lined with DURO-BOND rubber, protected with acid-proof brick lining, joined with LECITE. Norton filter plates supported on acid-proof piers, seen in foreground.

LECITE is one of EL CHEM's new corrosion-proof construction materials. Other EL CHEM materials include:

BRIMSO and Carbon-BRIMSTO — plasticized sulphur-base cement. Quick-setting. Withstand all inorganic acids (except strongly oxidizing) and mild alkalis, at temperatures to 200° F:

DURO-BOND — Seamless natural rubber lining. Compounded to meet specific requirements of unit.

DURO-XXX — Silicate, quick-setting cement. Impervious to all mineral acids except hydrofluoric.

DURO-SAN — Saran rubber lining. Applied in sheet form. Resists solvents and oxidizing acids. Withstands constant temperatures to 150° F. — and higher when protected by brick lining.

SYNTHO — Phenolic cement. Inert to all acids except highly oxidizing ones.

DURO-PRENE — Seamless Neoprene synthetic rubber lining. Vulcanizes at room temperature.

EL CHEM offers an all-inclusive service: materials, design — and construction by our own crews — every man a specialized worker in this specialized field. This means responsibility centered on a single source, no alibis, speedier installation, units into production usually much more quickly. Supervision by EL CHEM engineers offered if you prefer your own contractors.

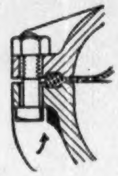
EL CHEM engineers with more than forty years experience in acid-proof construction for chemical, steel, food, and textile industries, are ready to study your corrosion-proofing problem, make recommendations and prepare plans and estimates, without obligation. Write for technical bulletin.

ELectro CHEMical
ENGINEERING & MFG. CO.
754-A Broad Street • Emmaus, Pa.
Manufacturers of acid- and alkali-proof cements, linings and coatings since 1912

Single wrench maintenance

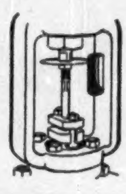
check these time and money-saving maintenance features

1



CAST FLATS make bolts easy to remove on superstructure. Heads can't turn . . . only one wrench needed.

2

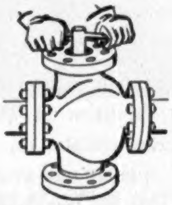


WIDE YOKE—plenty of room for big hands to work with that one wrench.

3

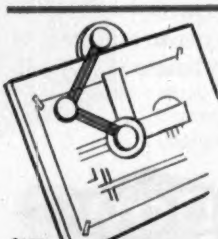
FLATS on valve stem use same adjustable wrench—does not score stem.

4



SEAT RINGS can be renewed without taking the valve body from the line. No vises, no lathes. Standard Leslie practice for 27 years, not a theory, a proven fact.

5

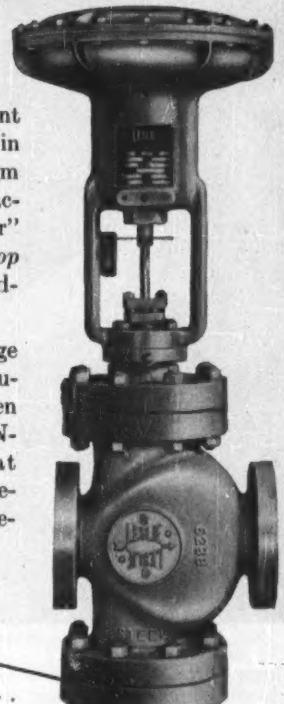


INTERCHANGEABLE parts keep inventory small, reduce down-time. Top grade materials and engineering means less maintenance.

2433

There are a host of important features found as *standard* in Leslie Double-Seated Diaphragm Control Valves usually manufactured only in "made-to-order" units — features that mean *top* performance and *extra*-dependable service.

But here's one more advantage that makes Leslie the most popular valve with maintenance men —SINGLE WRENCH MAINTENANCE. They find that maintaining the Leslie Double-Seated Control Valve is a one-tool job.



WHEN SPECIFYING . . .

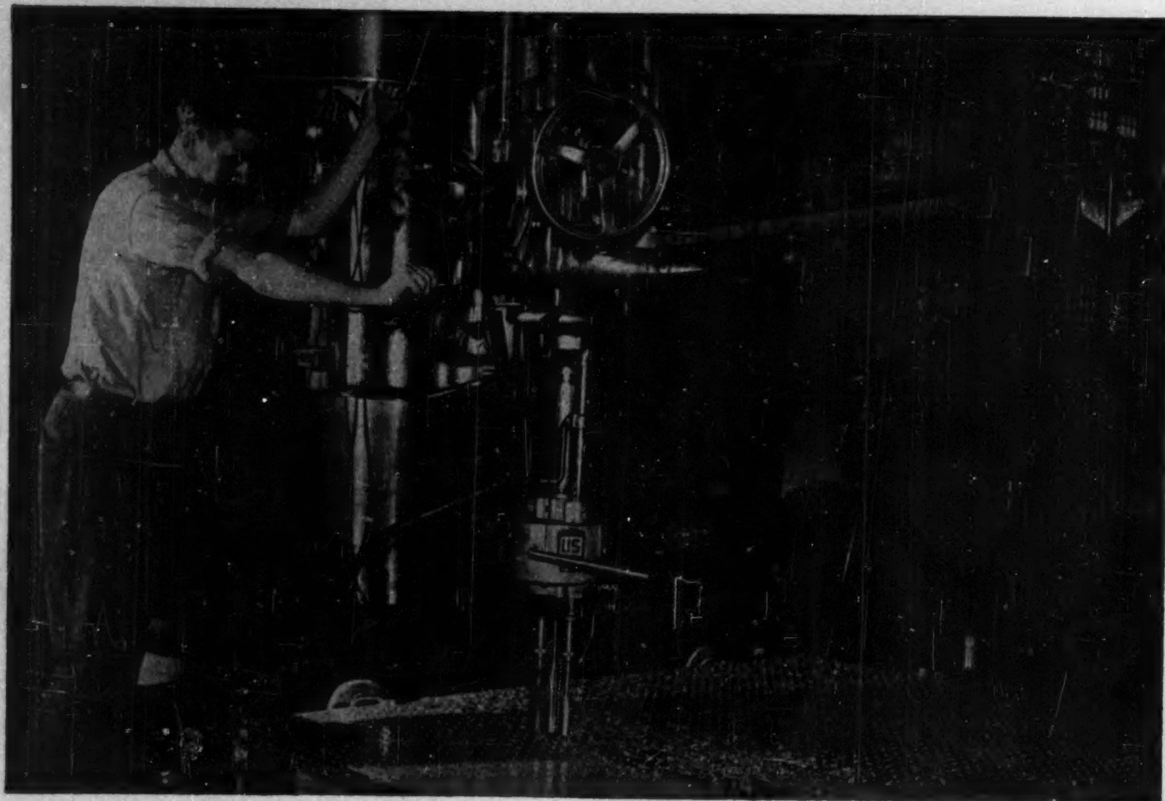
for pressure, temperature and level controls, a quick check can prevent ordering a *special* that Leslie makes as *standard*. A call to your Leslie Engineer, before you specify, is free insurance. He's listed under "Valves" or "Regulators" in the classified telephone directories in principal cities.

Send for free Bulletin 5305

12 new pages of valuable data on double-seated diaphragm control valves.

TRADE LESLIE MARK

LESLIE CO., 279 GRANT AVE., LYNDHURST, N. J.



EIGHT FOOT RADIAL DRILL at Alco's expanded Dunkirk plant has multiple head for the precision drilling or reaming of several holes simultaneously. Special machines like this, many of them Alco-designed, all of them operated by veteran craftsmen, are an important part of the Alco method of producing economical, effective answers to the toughest of metal-fabricating problems.

ALCO engineers and craftsmen provide...

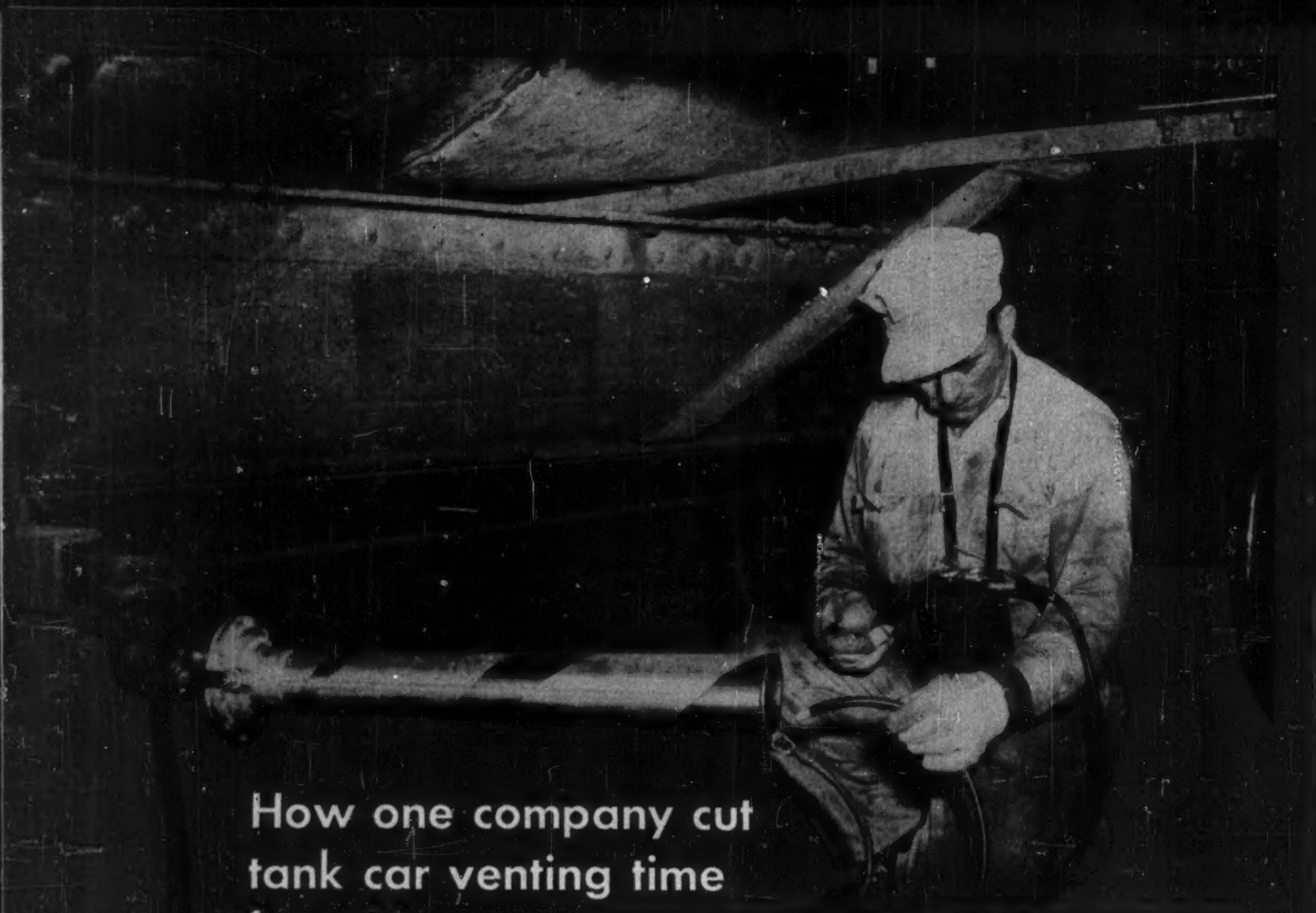
Answers to

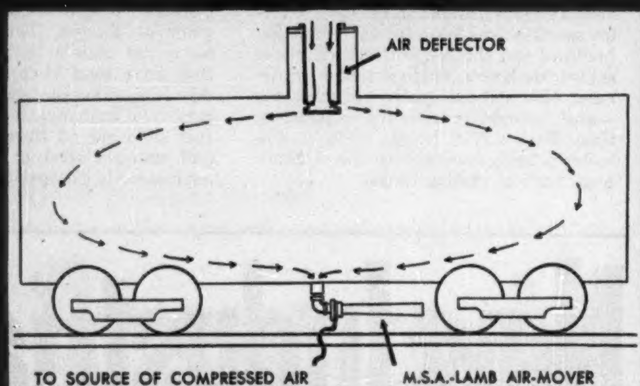
Through many years of working closely with engineers of petroleum, chemical, power and manufacturing companies all over the world, Alco has developed economical, effective methods of solving new industrial problems.

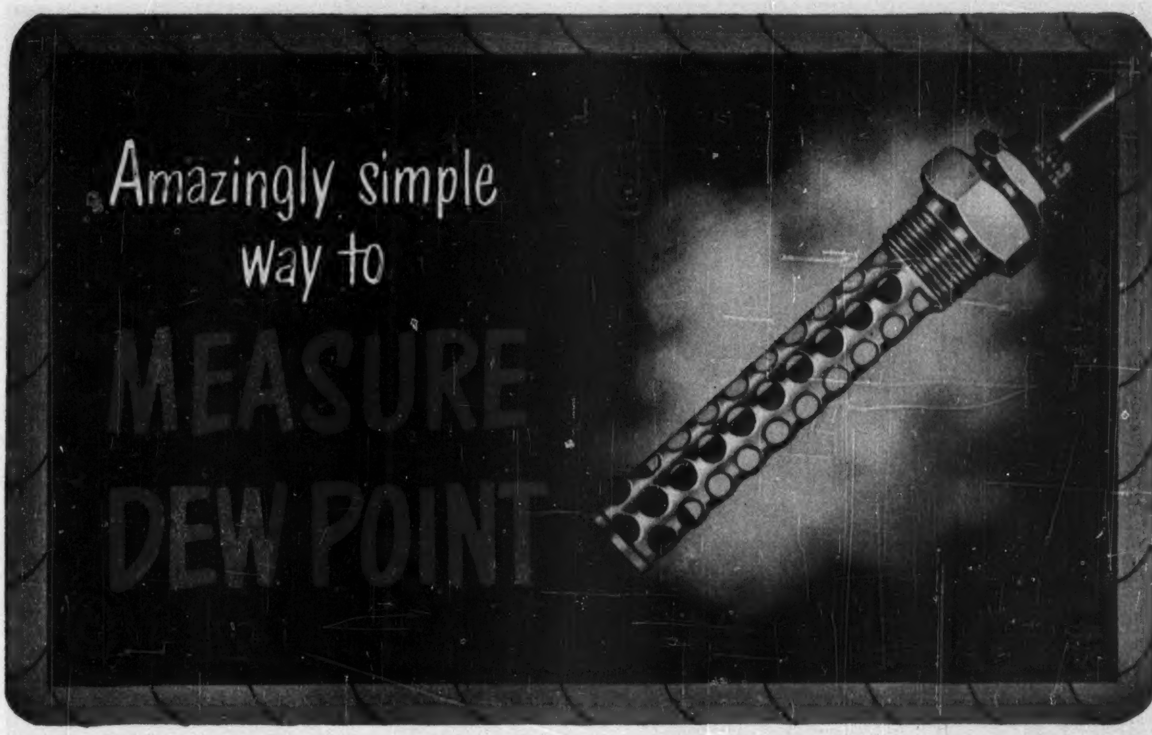
The first step is a thorough exchange of ideas between the client's production engineers and Alco's designers and mechanical engineers. Then, Alco prepares complete design details and fabrication specifications, leaving the client's engineers *free to concentrate on fundamentals.* Finally, veteran Alco craftsmen fabricate the finished product.

Result: substantial savings to the client in original equipment costs and, frequently, in subsequent operating costs.

Next time you have a metal-fabricating problem—a problem that calls for specialized equipment or new ways to speed up production—we invite you to let Alco work out the answer. Contact your nearest Alco Products Sales Engineer at New York, Chicago, Los Angeles, Kansas City, Houston, Tulsa, Beaumont, or write direct to Dunkirk, N. Y.


How one company cut
tank car venting time
from 16
to ONE hour
. . . safely . . .
with M·S·A
Equipment


AIR DEFLECTOR
TO SOURCE OF COMPRESSED AIR
M.S.A.-LAMB AIR-MOVER



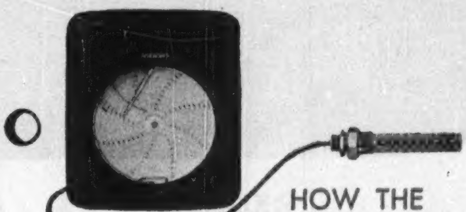
directly . . . accurately . . . continuously

Now you can measure or control the humidity of air or process gases with simplicity and accuracy never before obtainable!

An entirely new-type humidity-sensitive element, the exclusive Foxboro Dewcel*, opens many new possibilities for product improvement in industry. Coupled with a Foxboro Recorder or Controller, the Dewcel offers these outstanding advantages:

1. Direct recording in dew point temperature, at existing pressure.
2. Wide working range — even operates at sub-zero temperatures.
3. Neither adds nor removes water from atmosphere.
4. No water box or circulation of air required.
5. Simplicity that eliminates maintenance.
6. High sustained accuracy.
7. Initial and operating economy.

Investigate Foxboro Dew Point Control for your process. In successful use in nuclear fission, pharmaceutical, food and chemical plants, distilleries, photo film production, drying and storage operations. Write for Bulletin 407. The Foxboro Company, 366 Neponset Ave., Foxboro, Mass., U.S.A.



HOW THE DEWCEL* WORKS

The Dewcel element is a thermometer bulb (liquid-filled or electric-resistance type) jacketed with lithium-chloride-impregnated woven glass tape. Over this are wound two spaced gold or silver wires connected to an AC source. The lithium chloride absorbs moisture, allowing current to flow, generating heat, and raising the temperature. Equilibrium temperature is reached when vapor-pressure of the moist salt exactly balances that of the surrounding air or gas. The System translates this temperature into direct readings of dew point.

Thus, Foxboro Dew Point Instruments give direct readings or control of dew point from —50°F. to 142°F. at working temperatures from —40°F. to 220°F. Readings easily converted to absolute or relative humidity.

*Trade Mark

FOXBORO RECORDING CONTROLLING INDICATING INSTRUMENTS

FACTORIES IN THE UNITED STATES CANADA, AND ENGLAND

Another trainload of huge Pressure Vessels leaves Sun Ship's Chester plant.

If you're ever in the market for large high-pressure tanks—that's a good time to think of Sun Ship.

Construction of these giant tanks . . . whether for operating or for storage under pressure . . . whether for land or marine installation . . . has been an important part of Sun Ship's work for the petroleum and chemical industries for many years.

The trainload shown above, which includes tanks of 55,000-gallon and 30,000-gallon capacities—used for storing L.P.G.—typifies Sun Ship's experience in building large tanks which must carry pressure.

Shipments of these and of other huge vessels in carloads or trainloads is a familiar sight at the busy Chester plant. Fractionating towers, stills, catalytic cracking cases, reactors and other specialized equipment are turned out at Sun Ship's great and versatile plant on the Delaware, from which shipment can be made either by rail or by water.

Sun

SHIPBUILDING & DRY DOCK COMPANY

SINCE 1916

ON THE DELAWARE • CHESTER, PA.

25 BROADWAY • NEW YORK CITY

Any way you look at it this Thermometer is *Easy Reading*

You've been asking for a dial thermometer like this—A thermometer that can be positioned and firmly locked at any practical angle—now you can have it!

No stretching or straining to see this thermometer. Easy to adjust to required new positions before or after installation. No risk of the multi-angle selector working loose. A specially designed selector assures positive locking at every practical mounting angle and a few turns of *one* nut lock the selector securely.

These instruments, supplementing USG's complete line of Gotham temperature indicators, are designed to fit all standard connections and are available in all standard ranges. If you have a number of applications requiring "odd angle" mounting these new multi-angle thermometers will reduce the number and variety of instruments you have to carry in stock.

Before you order an angle thermometer be sure you see USG's new Gotham Multi-Angle Thermometer.

USG
UNITED STATES GAUGE

ADVANTAGES

1. Positive locking in every conceivable angle.
2. Reduces the number and variety of instruments required in your maintenance stock.
3. Provides that extra "odd angle" instrument which normal stock does not furnish.
4. Easy to change to any desired angle, before or after installation.
5. Saves engineers time when writing specifications.
6. Affords easy reading at odd angles.

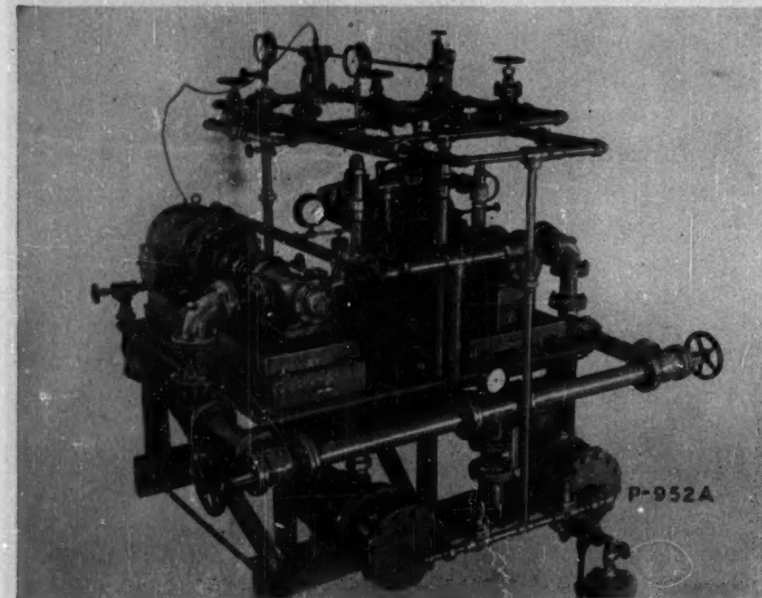
Dept. 3
United States Gauge
Division of American Machine and Metals, Inc.
Sellersville, Pa.

Gentlemen:
We'd like to know more about the new USG Multi-angle Thermometer. Please get in touch with us.

Name__________ Title__________
Company__________
Address__________
City__________ Zone____ State______

Now!

MORE COMPACT THAN EVER . .



P-952A—Steam Turbine and Electric Motor drive gives flexibility in this compact Model P-E52H size No. 25 unit.

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FUEL OIL PUMPING *AND* HEATING UNITS

NATIONAL AIROIL Fuel Oil Pumping and Heating Units are specially designed to prepare, for combustion, all grades of fuel oil including No. 6 or Bunker "C" Oil and residuums. They will draw fuel oil from above ground or underground tanks, preheat it to proper constant temperature and deliver it to Oil Burners at an even pressure, best suited for the burners. Our Fuel Oil Pumping and Heating Units are the result of years of experience. They come completely equipped ready for steam, exhaust, condensate, oil suction, oil return, and electrical connections. All valves, regulators, etc., are readily accessible. The piping arrangement is easily understood. These compact, space-saving units are available in a range of sizes and models in both Medium and High Pressure types. For complete details, write for our Bulletin 40 — very interesting and informative.

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- SLUDGE BURNERS, Steam Atomizing
- OIL BURNERS and GAS BURNERS for industrial power, process and heating purposes
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- DUAL STAGE, Combining Steam and Mechanical Atomization
- LOW AIR PRESSURE OIL BURNERS
- AUTOMATIC OIL BURNERS, for small process furnaces and heating plants
- GAS BURNERS
- COMBINATION GAS & OIL BURNERS
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Southwestern Division: 2512 South Boulevard, Houston 6, Texas

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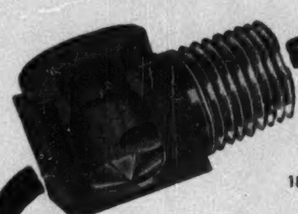

Available in Brass, Stainless Steel and Hard Rubber — or made-to-order in any machinable material. ¼" to 1" I. P. S.

Advanced design features a single round tangential inlet (instead of several small slots). Relatively large solid particles can pass right through and out the orifice. Produces a hollow cone spray with fine break-up and even distribution—ideal for many types of applications.

In many industries Monarch Spray Nozzles are used for:

- *ACID CHAMBERS*
- *AIR WASHING*
- *CHEMICAL PROCESSING*
- *COOLING PONDS*
- *DESUPERHEATING*
- *GAS SCRUBBING*
- *HUMIDIFYING*
- *OIL BURNERS*
- *SPRAY DRYING*

Let us send you Catalogs 6A and 6C

MONARCH MFG. WKS., INC.

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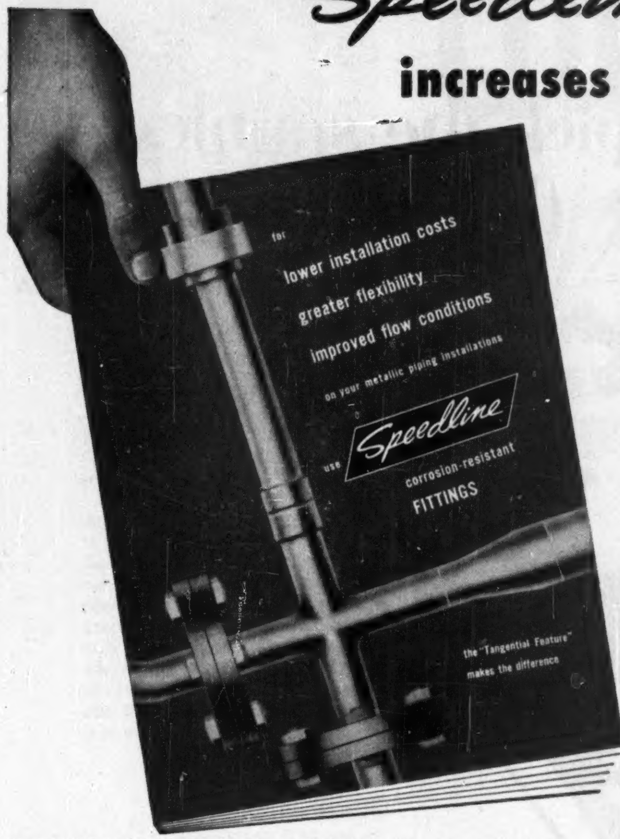
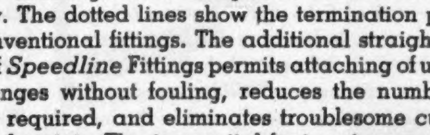
PHILADELPHIA 34, PA.

HOW TO SAVE MONEY ON STAINLESS PIPING

Speedline system cuts cost, increases flow and capacity



NEW 24-PAGE CATALOG describes and illustrates the many cost-saving advantages of *Speedline* Fittings with the "tangential feature". Size ranges and dimensions of all *Speedline* Fittings are also given along with helpful application information. Request your free copy on your company letterhead.



Look for the "Tangential Feature"

These drawings show a *Speedline* Tee and 90° Elbow. The dotted lines show the termination points of conventional fittings. The additional straight section of *Speedline* Fittings permits attaching of unions or flanges without fouling, reduces the number of welds required, and eliminates troublesome curved or angle joints. The tangential feature is common to all *Speedline* Fittings such as Ells, Tees, Crosses, etc.

● It will pay you to look into this new idea in corrosion-resistant piping. By using light wall stainless pipe and versatile *Speedline* Fittings, piping costs have been reduced 10% to 50%... and at the same time, flow and capacity of the line has been increased!

Here's the way it works:

If you are now using Stainless Pipe . . .

. . . chances are that it is the conventional Schedule 40. But this heavy wall is not needed in 90% of the cases. Light wall Schedule 5 pipe costs about half as much, and all sizes will easily withstand 150 p.s.i. working pressures. *Speedline* Fittings are specially designed for fast, low-cost installation of light wall stainless pipe lines. And because light wall pipe of the same size has a larger inside diameter than heavy pipe, you gain 15% to 25% greater flow and capacity!

If you are now using Stainless Tubing . . .

. . . the *Speedline* system offers real savings and advantages. It permits you to change to a light wall *pipe* rather than *tubing* size—at no increase in cost. And here's where you gain. Standard equipment like valves, pumps, sight gauges, etc., are made in *pipe* sizes—you hook right in without special adapters! And equally important, *piping* permits you to use the next lower dimension (for example, 1" Sch. 5 pipe has even greater capacity than 1¼" O.D. tube). This means that you can use smaller valves, flanges, and other accessories—an entire installation would be considerably lower in cost.

Speedline distributors are located in principal cities from coast to coast

Speedline **Corrosion-Resistant FITTINGS**

—the newest thing in pipeline economy

Manufactured by **HORACE T. POTTS CO.** • 500 E. Erie Avenue • Philadelphia 34, Penna.

pick the stainless that fits best

When selecting stainless steel be sure you pick the correct type for your particular application. For some grades resist corrosion better . . . others have superior heat resistant properties. Some are easier to machine . . . still others can be more readily formed or welded.

In every case there is a grade of Crucible REZISTAL Stainless Steel that is best suited to the job. And to help our customers select the type that will provide the best service for the lowest cost, we make available all the design, metallurgical, fabricating and application data we have accumulated in our years of stainless steel experience with many different industries.

Our staff of field representatives brings you the benefit of our vast technical resources. And the quality of REZISTAL Stainless Steel sheets, strip, plates, bars, wire, forgings, castings and tubing produced in our modern integrated mills is unsurpassed in the industry. When you have an application for stainless, call Crucible.

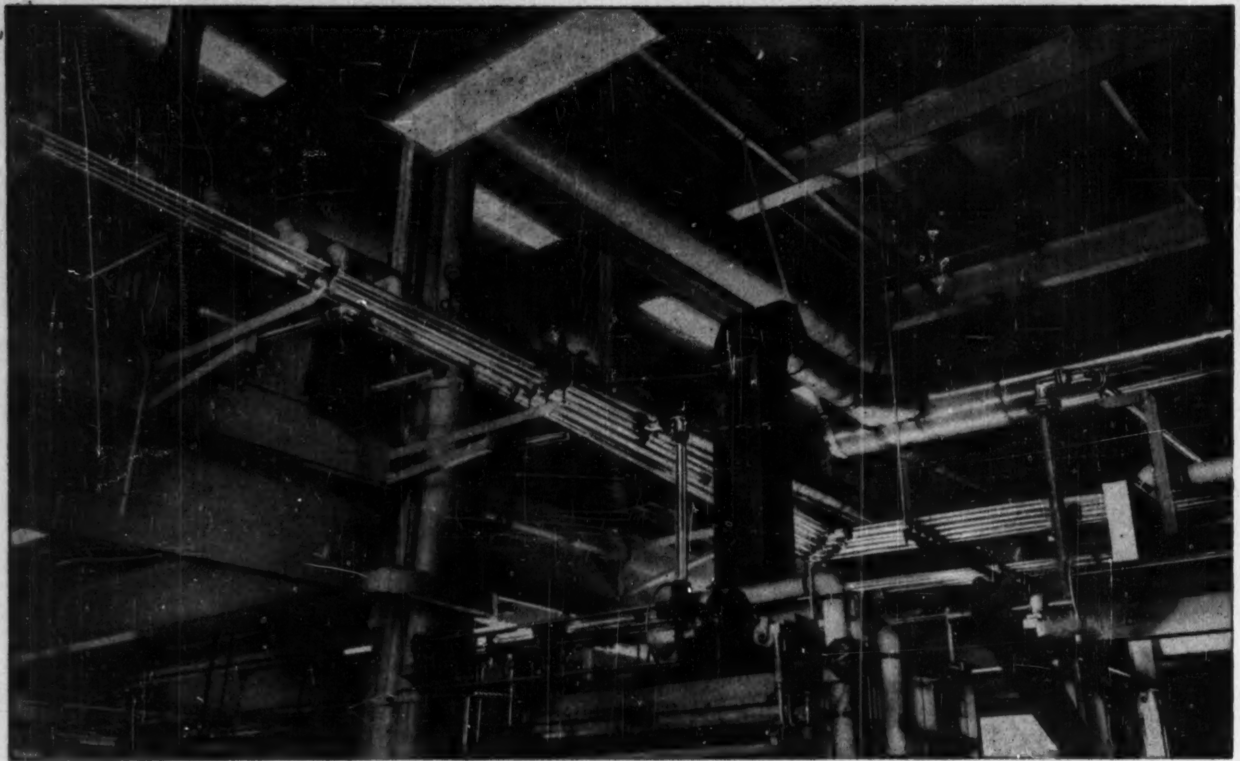
Write for free copy of "Making the most of Stainless Steels in the Chemical Process Industries".

CRUCIBLE first name in special purpose steels

53 *years of Fine steelmaking* **STAINLESS STEEL**

CRUCIBLE STEEL COMPANY OF AMERICA, GENERAL SALES OFFICES, OLIVER BUILDING, PITTSBURGH, PA.

STAINLESS • REX HIGH SPEED • TOOL • ALLOY • MACHINERY • SPECIAL PURPOSE STEELS



How this chemical dye user *protects sensitive products in process*

...and gets 2 other advantages with Pyrex® brand Glass Pipe

When Bachman Uxbridge Worsted Mills prepared to select a piping material, they set up three requirements:

1. It must be noncontaminating in transferring highly sensitive dyes from a central mixing station to dye kettles. Dye shadings are extremely sensitive to metallic contamination.
2. It must be easy to clean. And the cleaning had to be positive and provable so that colors could be switched rapidly.
3. It must assure real economy in cost of installation, maintenance and service life.

PYREX brand "Double-Tough" glass pipe met these requirements so well that this Uxbridge, Mass. textile mill has 25 lines in various lengths from 25 to 100 feet.

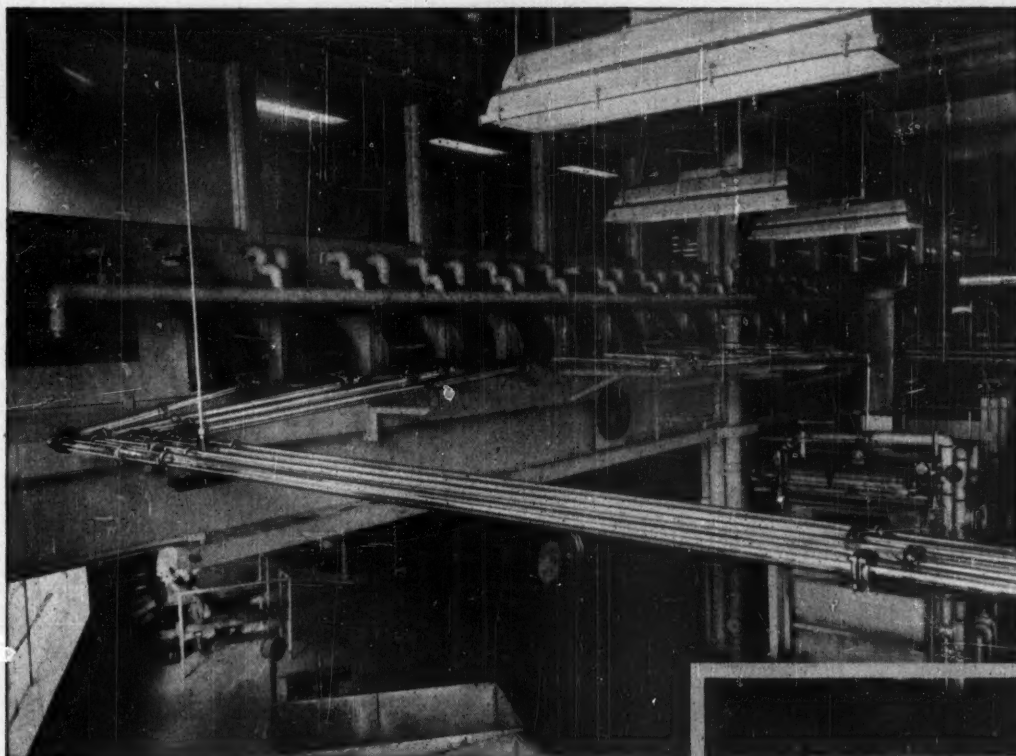
The exceptional chemical stability and corrosion resistance of PYREX pipe makes it ideal for the most sensitive dyes and pharmaceuticals as well as hot, concentrated acids (except hydrofluoric) and mild caustics.

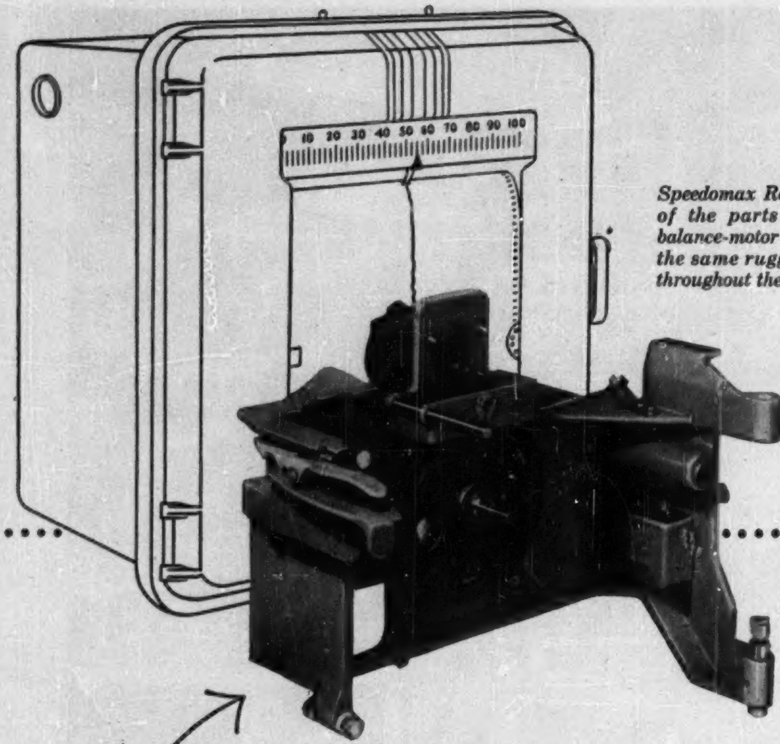
Easy cleaning is assured by its hard, smooth surface, free of pits and truncations. When it is clean, the transparency of glass lets you see that it is clean . . . also enables you to detect air locks and impediments in the lines.

PYREX brand glass pipe is actually the most economical corrosion-resistant piping material on the market today. First cost is reasonable. Your own men can install it. And it is sure to provide long, troublefree service . . . not only because it cannot be eaten away by acids, but because it has a high degree of physical and thermal strength.

The name of your conveniently located, qualified PYREX pipe distributor is listed at right. Contact him today for the facts on this efficient, money-saving material . . . or mail the coupon.

CORNING GLASS WORKS





Speedomax Recorder and a few of the parts for its circuit-balance-motor drive. You'll find the same rugged construction throughout the instrument.

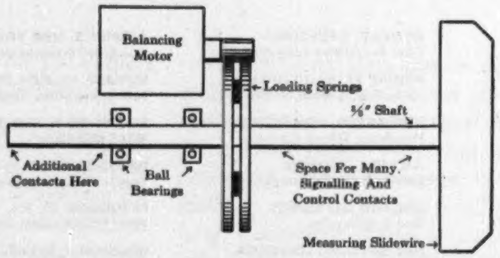
RIGID CONSTRUCTION MEANS Rigid Dependability

● When you turn a measuring or control job over to a Speedomax instrument, much of the good performance you receive is due to the strong, carefully-assembled mechanism controlled by the sensitive electronic circuits. Seasoned, time-proved mechanical design is evident as soon as you open the instrument door.

For instance, just rotate the "big" balancing-gear train with your fingers. You won't detect back-lash. The train will turn at a touch, but those two ⅛" face, spring-loaded gears are held so snugly against the pinions, in opposite directions, that they answer every tiny balancing motion in either direction. The slightest nudge from the "huge" 12-watt balancing motor therefore goes straight to the slidewire, recording and control mechanism via their common shaft. The tying of these functions to one shaft assures permanent alignment of recording, control and measuring functions.

The paper drive and some other components get their positive action in another way. They use machined, heat-treated worm gearing for snug fit and precise motion. Ability to use such designs is one of the many advantages of the instrument's ample power. Liberal use of ball bearings is another quality feature, to transmit full power, reduce routine attention and maintain operating precision.

As you look further into a Speedomax, you'll also note that many parts such as frame castings, shafts, linkages, etc., seem very large. But there's a strong reason for this seeming oversize—it prevents mechanical deflections in operation. Rigid construction gives rigid dependability.



The Speedomax Mechanism "Heart" Is Just 2 Assemblies

Why not inspect these and other evidences of quality the next time you need an electronic potentiometer or bridge. You can easily check them against the general description in our Catalog ND46(1). If you're interested in research, ask also for Technical Publication ND46(1). Address our nearest office, or 4916 Stenton Ave., Philadelphia 44, Pa.

LEEDS NORTHRUP

instruments *automatic controls • furnaces*

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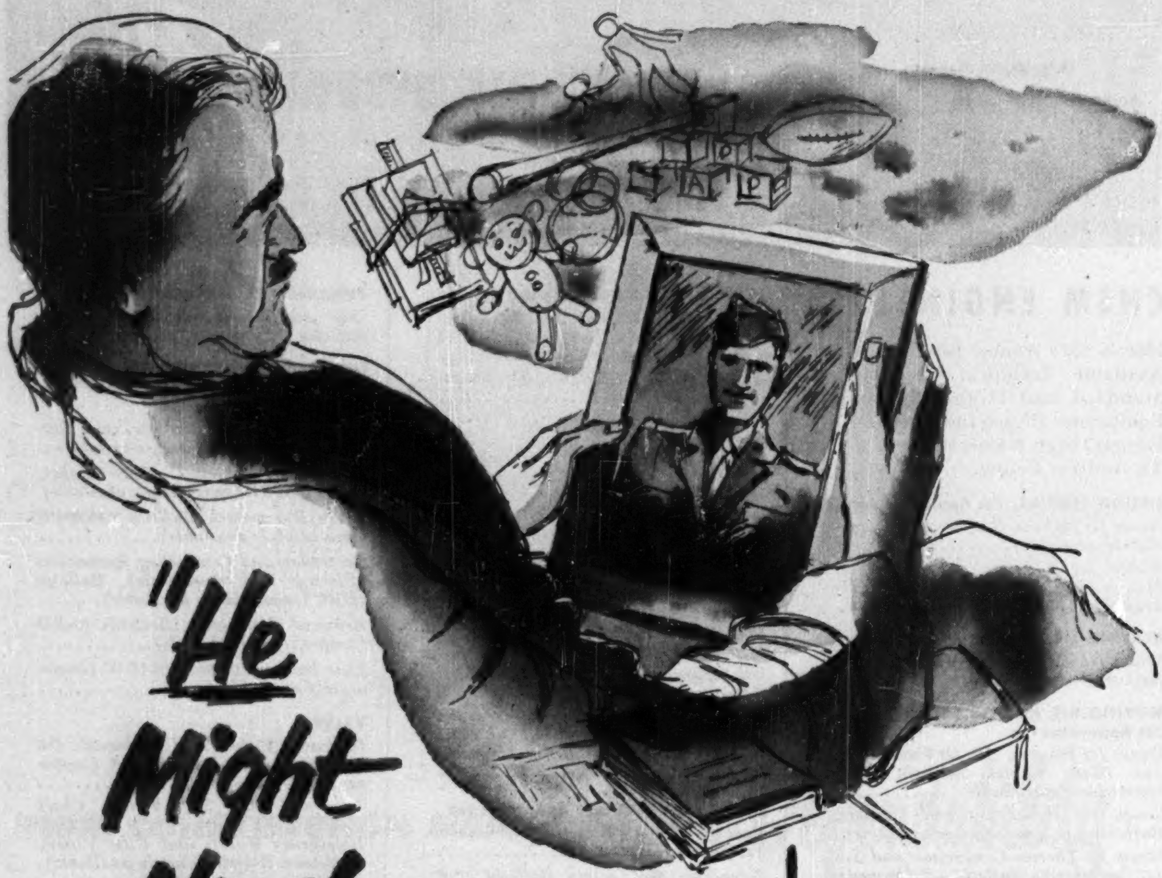

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MERRICK SCALE MFG. CO.
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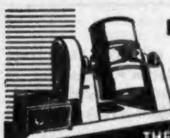

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SINGLE OR DOUBLE
For prices and information

WRITE TO THE CLEVELAND MIXER CO.
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Cleveland 9, Ohio

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SERVICE IN THE FIELD OR IN OUR PLANT

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CORROSION-PROOF CEMENTS

offer complete resistance to both acids and alkalies in steel mills, chemical plants and processing industries. Send blue-prints or sketches, so we may recommend proper cement to use. Write for latest catalog.

TRIAL ORDER
FOR ACID AND ALKALI USERS
Handy quart cans for making comparative tests—8 different cements. **$7.50**

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CHEMSTEEL CONSTRUCTION COMPANY, INC
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of processing & storage tanks & flooring.

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ADDRESS..............................
CITY............ZONE......STATE....

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CHEMISTS AND Chemical Engineers Wanted. The Tennessee Valley Authority wants Chemists and Chemical Engineers to carry on inorganic research and development activities in chemical plants at Wilson Dam, Alabama. Several vacancies also exist for Chemists for plant chemical control work. Salaries start at $4575 and $5450 for 40-hour week. All Jobs carry automatic within-grade increases for satisfactory service, liberal vacation leave, sick leave, and retirement benefits. Write to Tennessee Valley Authority, Division of Personnel, Knoxville, Tennessee.

WANTED: GRADUATE Engineers, preferably chemical, for both Consulting and Field Sales Work. For Sales, should have 3 or more years successful record. For Consulting, young men preferred so that our business can be taught to them and they can move up in years to come. Write P-7876, Chemical Engineering.

WE HAVE an opening for a man with the ability and experience to eventually head our Research and Development program. Experience in the adhesive or coating field is desirable. Starting salary will be commensurate with ability. Advance Coating Company, Depot Road, Westminster, Massachusetts.

CHIEF CHEMIST—Salary open, excellent opportunity, experience in adhesives. Please mail resume. Industrial Latex Company, Wallington, N. J.

GENERAL MANAGER. Small, progressive, midwest, chemical company desires senior executive with considerable experience in organic chemical field and knowledge of pharmaceutical industry to expand existing operations and direct production, research and sales. Age: to fifty. Reply giving details of education, experience, and salary requirements. Replies held in strict confidence. P-7913, Chemical Engineering.

(Continued on the following page)

GRADUATE ENGINEERS

Graduate engineers for process and development engineering positions with Michigan manufacturer of enamel magnet wire and cable. Openings for both experienced and interested men in this field. Write stating training and qualifications. Reply will be held strictly confidential.

P-7630, Chemical Engineering
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Resin Development Chemist
Chemical Engineer

For Research & Development Department of a modern Coated Abrasives plant belonging to a large, national company. Prefer graduates with 1-5 years experience in resins or coated products, but not necessary. Excellent working conditions. Send complete resume. Indicate salary requirement.

P-7711, Chemical Engineering
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for large copper company Chile, South America. Must be experienced in analytical work of all kinds, including complete analysis of ferrous and non-ferrous metals etc. Three year contract. Transportation both ways and salary while traveling paid by Company. In reply give complete details.

P-7561, Chemical Engineering
330 W. 42 St., New York 36, N. Y.

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WANTED

By leading New England manufacturer of processing equipment. Chemical engineering education and experience is essential. The right man for this job will be under 35 years of age, willing to travel, capable of capitalizing on the company's established reputation and excellent development, research and testing facilities. Good pay, excellent opportunity for advancement with a solid satisfying future. Write, giving age, education and experience.

SW-7875, Chemical Engineering
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Are you experienced in buying, selling, appraising used machinery for the process industries? This is an EXCEPTIONAL OPPORTUNITY for a capable, enterprising man to take complete charge and to earn large commissions. We have complete reconditioning facilities. Send complete information: experience, age, present and past earnings. This is a rare offer—write immediately, if experienced, or if you know someone who is qualified, please pass this on. Confidential.

SW-7800, Chemical Engineering
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Interview at your convenience.

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(Continued from preceding page)

EMPLOYMENT SERVICES

SALARIED POSITIONS $3,500 to $35,000. We offer the original personal employment service (established 43 years). Procedure of highest ethical standards is individualized to your personal requirements. Identity covered, present position protected. Ask for particulars. R. W. Bixby, Inc., 262 Dun Bldg., Buffalo 2, N. Y.

SALARIED PERSONNEL, $3,000-$25,000. This confidential service, established 1927, is geared to needs of high grade men who seek a change of connection, under conditions assuring, if employed, full protection to present position. Send name and address only for details. Personal consultation invited. Jira Thayer Jennings, Dept. B, 241 Orange St., New Haven, Conn.

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MANUFACTURERS REPRESENTATIVE solicited, water stills, sterilizers, and hospital and laboratory equipment manufactured by the Consolidated Machine Corporation, 49 Sudbury St., Boston 14, Mass.

SALES ENGINEERS, with experience in the sale of mechanical equipment, wanted for positions involving general application and sale of heating, ventilating, and air handling apparatus for commercial and industrial buildings, industrial processes, and mechanical draft. Positions are available in the Southeast and Great Lakes regions. Personal interviews will be granted only after receipt of written application giving full details of experience. Address: Sturtevant Division, Westinghouse Electric Corporation, Dept. AH, Hyde Park 36, Boston, Mass.

POSITIONS WANTED

CHEMICAL ENGINEER BS has the following requirements; ability (B+ college average), theoretical and practical knowledge of many chemical processes, analytical minded, hard worker, excellent "Trouble shooter", and enough leadership to handle plant personnel. I have done with ease technical and engineering work (designed many experimental and plant installations), trained groups of supervisors and supervised a variety of chemical plants. I have always done an excellent job. Available now. $5500 a year. Age 42. Located N.J. but will relocate. PW-7887, Chemical Engineering.

INDUSTRIAL ENGINEER 35, graduate, 14 yrs. exp. design & estimating in conn. with construction of chemical & industrial plants. Responsible. Presently employed as piping engineer. Seeks relocation with future. Prefer South or East. PW-7897, Chemical Engineering.

ADMINISTRATIVE CHEMICAL Engineer — Registered P.E., age 37, experienced production, plant, general superintendent, production manager; fifteen years chemical plant administrative experience in alcohol, whiskey, rayon-cellophane, fertilizer, sulfuric acid, soybean oil solvent extraction, submerged fermentations, commercial yeast, riboflavin, Vitamin B-12. Also interested other fields. Very adaptable. PW-7917, Chemical Engineering.

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Unlimited soft water and city sewage. Brick garage 10,000 sq. ft. sprinklered and heated. Easily accessible to various communities, highways and turnpike. Plant now operating with plentiful local labor.

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STAINLESS STEEL PREMIER COLLOID MILL

Paste type, direct coupled to geared-up 30 H.P. motor. 8" Rotor at 7200 R.P.M. Jacketed for heating or cooling. Operated 15 hours. Guaranteed condition at 50% factory cost.

Windemere Sales Co. Red Hook, N. Y.

WANTED

READY TO BUY

Dyes - Chemicals - Pigments - Waxes
Plasticizers - Solvents - Colors
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CHEMICAL SERVICE CORP.
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Vacuum Dryers, Heavy Duty Mixers, Reactors, Kettles, Columns, Rotary Filter, Pulverizers, Filter Presses, S/S and non corrosive Tankage. Idle or Set Up Plant.

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Chuch St. Sta. New York 8, N. Y.

Additional Position Vacant Advertising on Pages 511 & 514

senior process engineer

Permanent, challenging position on our process staff for a Chemical Engineering graduate with 8 to 10 years experience in petroleum or petrochemical fields.

Our organization has an international reputation and is located on the East Coast.

This man must have the capacity to assume responsibility for process design and development and the potential to supervise other process engineers.

Our salary offer is high, and in addition, we have a liberal pension plan, accumulative vacation policy, and other employee benefits. We will pay for your traveling and moving expenses.

Please write details of your experience and education, salaries received and include your initial salary requirements. Complete privacy is assured since our personnel have been advised of this opening.

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Chemists, Physicists, ChE's, ME's

WHY YOU SHOULD CONSIDER A CAREER AT CELANESE

One of the country's most research-minded organizations, Celanese provides an ideal working environment in its modern laboratories. An established policy of promotion-from-within makes advancement an ever-present possibility for men who show initiative and leadership qualities.

Current positions are for men with the following experience:

TEXTILE RESEARCH PHYSICISTS: BS, MS or PhD in Physics, Chemistry or ChE, experience in textile research.

GRADUATE ChE's, CHEMISTS OR PHYSICISTS: 0-2 years' experience, to do creative work in one of the following fields: synthetic organic pilot plant activities; polymer chemistry; cellulose derivatives; dyeing and finishing; physical measurements; optical research; or instrumentation.

SENIOR TEXTILE CHEMIST: Accredited textile chemical school graduate, 3-5 years' experience in research and development of textile chemicals or in dyeing and finishing.

TEXTILE RESEARCH ENGINEERS: Minimum BS in Physics, ME, CE or diploma from recognized textile school. Some experience in the textile industry.

Our current expansion program has created openings in our Summit, New Jersey Research Laboratories (acquired in 1945, these laboratories provide ultra-modern equipment) and in the plants and research laboratories of the Chemical Division in Texas, and in our textile plants in Maryland, Virginia, South Carolina, as well as some foreign locations.

Please submit resume to Mr. S. B. McFarlane

Celanese CORP. OF AMERICA
MORRIS COURT, SUMMIT, NEW JERSEY

CHIEF ENGINEER

Progressive Canadian concern seeks graduate mechanical engineer with at least five years experience in the design of pressure vessels, heat exchangers and bubble trays. Should have a good general knowledge of the equipment for the petroleum and petrochemical industry.

In applying, furnish a detailed resume of your education, experience, reference and a recent snapshot. Salary open.

P-7785, Chemical Engineering
68 Post St., San Francisco 4, Calif.

ELECTRICAL and INSTRUMENT ENGINEER

Responsible for the maintenance and installation of electrical equipment and instruments in a complete refinery of an independent oil company located in the southwest. Must have a degree in electrical engineering and at least 5 years experience in a refinery. Will assist Chief Engineer in developing specifications for electrical equipment and instruments. Will supervise the installation and maintenance of same. Salary open subject to experience and qualifications.

P-7814, Chemical Engineering
520 N. Michigan Ave., Chicago 11, Ill.

Engineering Editor

Permanent position with good opportunity for qualified engineer attracted to technical editing and writing. Requires degree in chemical engineering with 3-10 years of practical experience in the chemical or chemical process industries. Prefer experience in production, development, engineering or design work. Must be alert, able to think logically and write clearly. Location Metropolitan New York. Please state personal data, education, experience, references and salary requirements.

P-7420, Chemical Engineering
330 W. 42 St., New York 36, N. Y.

LUBE OIL BLENDING and PACKAGING SUPERVISOR

Responsible for the operations of a modern blending and packaging plant which is a part of a complete refinery of an independent oil company in the southwest. Must have thorough knowledge of drum reconditioning, drum and can filling, box car shipping, and lube oil blending operations. College degree preferred. Salary open subject to experience and qualifications.

P-7811, Chemical Engineering
520 N. Michigan Ave., Chicago 11, Ill.

Additional Position Vacant Advertising on pages 511 & 512

Cast Your Eyes Over These BRILL Buys!

Outstanding Selections Backed by Our Quarter Century of Service and Dependability!

DRYERS—KILNS

1—Vulcan 7'x160', ⅝" shell, two 12" tires complete.
1—Vulcan 7'x120', ⅝" shell, two 12" tires complete.
2—Allis Chalmers 9'x80', ⅝" shell, 2—12" tires complete.
1—5'6"x25', ½" shell, two 6" tires.
1—Louisville 38"x25' steel Hot Air Rotary Dryer.
4—Rotary Dryers 7'x60', 5'x67', 4'6"x50', 3'x25'.
2—Hersey 6'x23', 5'x23' Hot Air Rotary Dryers.
4—Louisville Steam Tube Dryers 6'x50', 6'x30', 5'x28', 3'x20'.
4—Buflovak single door vacuum shelf Dryers having 20—42"x42" shelves.
4—Devine single door vacuum shelf Dryers, having 20, 8, 6 and 4-40"x43" shelves.
5—Stokes & Buflovak Rotary Vacuum Dryers 30"x8', 3'x15', 6'6"x38'.
1—Single Drum 4'x9' Flaker.
1—Single Drum 60"x80" Flaker.
1—14 Truck steam heated Dryer 1680 sq. ft.
3—Buflovak 6' diameter, Vacuum and Atmospheric Crystallizers.

FILTERS

2—Oliver Monel 8'x10' Rotary-Vacs.
1—Oliver SS 8'x10' Rotary-Vac.
2—Eimco 4'x5' Rotary-Vacs complete with pumps, drives, piping, etc.
3—Oliver 5'3"x3', 3'x1' Rotary Vacuum Enclosed Precoat.
8—Oliver Rotary Vacuum 11'6"x18', 11'6" x14', 8'x12', 8'x10', 8'x8', 8'x6', 3'x1'.
1—Feinc steel 8'x12' Rotary-Vac.
2—Sweetland #12 with 72 and 36 leaves.
1—Sweetland #10 with 18 leaves.
1—Sweetland #7 with 27 leaves.
3—Vallez 500 sq. ft. Rotary Pressure.
1—Sperry 36" Recessed, 48 chambers, c.i., open delivery.
5—Shriver 30" P&F, 30 chambers, c.i., open delivery.
8—Sperry 24" P&F, 16 chambers, c.i., closed delivery.
1—Shriver 24" Recessed, 30 chambers, c.i., open delivery.
3—Shriver 18" Recessed, 30 chambers, c.i., open delivery.
2—Sperry Aluminum 30" and 24" P&F, 22 and 26 chambers.
10—Shriver Sperry Filter Press Skeletons 42" to 18".

CENTRIFUGALS

1—Bird 48" Suspended steel, bottom discharge, perforated basket.
1—Fletcher 48" Suspended Aluminum bottom discharge, perforated basekt.
1—Fletcher 40" Suspended, SS, bottom discharge, perforated basket.
1—Tolhurst 32" Suspended Monel, bottom discharge, perforated.
1—Fletcher 30" Suspended Steel, bottom discharge, perforated.
1—Tolhurst 30" Suspended Rubber, bottom discharge, perforated.
1—Tolhurst 26" Suspended, steel, bottom discharge, perforated.
2—Bird 36"x50" solid bowl, rubber and stainless.
4—Bird 36"x72", 36"x50", 24"x38", 18"x 28" solid bowl continuous, steel.
2—Sharples #16P Monel Super Centrifuge.

LOOK!

2—Link-Belt 6'4 x 24' Roto-Louvre Dryers 316 SS.
1—Link-Belt 3'10" x 14' steel Roto-Louvre Dryer.
1—Hersey 4'x26' Monel Hot Air Rotary Dryer.
1—Hersey 3'x24' Stainless Steel Hot Air Rotary Dyrer.
1—Electro Dryer, size X, Type CH, 3000 cu.ft.
1—Kritzer Lime Hydrator, 6 stage, 14' dia.
1—Goslin Birmingham 4'x8' solid nickel Flaker.
1—Link Belt 2'7"x8' Monel Roto-Louvre Dryer.
2—Milton Roy Duplex Proportioning Pumps, 212 GPH at 1500# pressure.
1—Baker Perkins 35 gal. stainless steel, jacketed, double arm Mixer, Sigma Blades.
1—Day 50 gal. stainless steel jacketed, double arm Mixer, Sigma Blades.
4—Pfaudler New 1500, 1000 gal. glass lined Reactors.
1—#2TH stainless steel Mikro Pulverizer.
2—Closed stainless steel Tanks 1500 and 1000 gal.
1—Hardinge 4½' x 16" Conical steel lined Ball Mill 30 HP.
1—Banbury #1A Mixer with 100/50 HP motor.
5—Heat Exchangers stainless steel shell and tubes 50 to 300 sq.ft.
2—Pfaudler 100 gal. glass-lined Stills with condensers and receivers.

PULVERIZERS

1—Bauer 36" Attrition Mill 2-50 HP mtrs.
8—Patterson 6'x8', 5'x6', 4'x5', 4'x4½' Pebble Mills.
5—Abbe 3'x4', 3'x3½' Pebble Mills.
2—Premier Colloid Mills 8" dia., SS.
1—Eppenbach QV7 Colloid Mill.
1—Jeffrey 36"x24", Hammer Mill.
3—Raymond, Gayco Mechanical Separators 14', 12', 4'.
2—Mikro No. 1SI, No. 1SH Pulverizers.
1—Fitzpatrick Comminuting Mill, 5 HP.
2—Sturtevant 5"x8" Roll Crushers.

SCREENS

5—Sprout Waldron SS, single deck, 40"x 84".
1—Day Ro-Ball single deck 40"x120".
4—Rotex #42, #22, and #11 single and double deck Screens.
1—Robinson double deck 20"x50".
5—Tyler Hummer 3'x5' triple deck.
6—Tyler Hummer 3'x15', 3'x10', 3'x5' single deck.
1—Abbe #2 blutergess Sifter.
1—Selectro Double Deck 18"x48".

MIXERS

1—Baker Perkins JUMM jacketed, double arm, dispersion blades, 100 HP.
2—Baker Perkins, Size 18, 300 gal. jacketed, double arm, sigma blades Vacuum.
1—Baker Perkins 300 gal. Unidor stainless steel.
1—Day 30 gal. Imperial, jacketed, double arm, sigma blades.
1—Baker Perkins ½ gal., jacketed.
1—Patterson 5' dia. Conical steel.
1—Day 2000# steel Powder Mixer.
1—Robinson 4000# steel Powder Mixer.
6—Rodgers 200 to 3000# Powder Mixers.
8—New Portable Agitators ¼ to 5 HP.
4—Day, Ross 8 and 50 gal. Pony Mixers.

MISCELLANEOUS

10—Bucket Elevators steel housing 34' to 60' centers, 8"x5", 10"x6" buckets.
1—Lummus 4' dia. steel bubble cap Column.
4—Buflovak, Zaremba and Kilby Evaporators, single and multiple effect, 300 to 16,000 sq. ft.
7—Stokes Vacuum Pumps 15 to 100 CFM.
5—Devine, Buflovak, Condensers and Receivers, 20 to 90 sq. ft.
1—Newman 2500# Soap Crutcher.
4—Groen 150, 125 gal. stainless steel, jacketed, agitated Kettles.
8—Stokes DD2, BB2, D4, D3 and B2 Rotary Tablet Machines.
4—38" dia. stainless steel Revolving Pans.
3—Nash #TS12, AL671 and #4 Vacuum Pumps.
7—Olivite, Duriron, rubber, Karbate and Haveg Centrifugal Pumps 6" to 2".

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International Stainless Steel Straightline Vacuum Filler, 160 per minute.

Resina LC automatic Capper.

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F.M.C. Kyler A adj. Wraparound Labeler.

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S. & S. G1, G2 and G6 Auger Fillers.

Colton 2, 3RP Rotary Tablet Machines.

Stokes 2 Cream Filler and Closer.

Triangle Elec-Tri-Pak G2C, A6CA Fillers.

Filler 4-Head and Hope 6-Head Stainless Steel Piston Fillers.

2000 gal., 500 gal. Jacketed Mixing Tanks.

Horix S. S. 14-Head Rotary Filler.

Standard Knapp No. 429 Carton Sealer.

Mikro 4TH, 3TH, 2TH, 1SH and Bantam Pulverizers; Schutz-O'Neil Mills.

Tri-Homo #5 Colloid Mill, 7½ HP.

3500 gal. working cap. Steam Jacketed, Double Arm Mixing Tanks for mixing, storing or processing of your materials.

Day 650 gal. Steam Jacketed Mixer.

B. P. 150 gal. Unidor S. J. D. A. Mixer.

Stokes, Day, New Era, Hottman Mixers, from 2 to 450 gal., with and without Jackets, Single, Double Arm Agitators.

Baker Perkins and Readco Heavy Duty 6 to 150 gals. Double Arm Jacketed Mixers with Sigma or Fish Tail Blades.

J. H. Day 8 gal. Pony Mixer.

Day 100, 800, 1500, 10,000 lbs. Dry Powder Mixers and Sifters.

Lee 85 gal. S. S. Jacketed Mixing Kettle.

Pony M, ML Labelrites; World and Ermold Rotary and Straightway Labelers.

Shriver 24" Jacketed, Oliver, Sweetland #2, Sparkler, Alsop Filters.

Pneumatic Scale Cartoning Line.

Oliver cellophane adjustable Wrapper.

Hayssen 8-18 adj. Wrapper for Kraft or cellophane.

Hudson Sharp Campbell 2W6 high-speed automatic cellophane Wrapper.

Package Machy. DF, FA4, FA Wrappers.

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SPECIAL: 5' x 15' Rotary Kiln Brick Lined Complete

DRYERS & KILNS

Devine #12 Vac. Shelf Dryer, 40"x42" shelves.
2—Ruggles Coles 7½' x 60' & 6' x 45' Rotary Dryers.
1—6 fan automatic Conveyor Dryer.
2—Albright-Nell 4' x 9' Atmos. Drum Dryers.
1—Buffalo Vac. Drum Dryer 24" x 20".
Gehnrich Gas Fired Dryer, 12 trays 21" x 32".
6—Steam, Gas & Electric Dryers, Tray & Truck.
New Sees Rotary Dryers & Kilns, good deliveries.

CENTRIFUGALS & CENTRIFUGES

5—Tolhurst 40" Suspended Type Centrifugals. Bottom Discharge. Motor Driven.
8—Centrifugals 26", 30", 40", 42" & 48", Steel, Copper, Stainless & Rubber Lined.
12—Sharples Centrifuges #5A Stainless. Also #6.
3—De Laval Multiple Clarifiers #200, 300 & 301.

FILTERS

1—Vallez 41 Stainless Covered Leaf Filter, type 40.
10—Sperry & Shriver 12", 18", 24", 30", 36", Iron & Wood Filter Presses.
Sweetland & Oliver Rotary Vac. Filters.

KETTLES & TANKS

1—Dopp 350 gal. CI Agit. Jack. Vac. Kettle.
Devine 30" dia. Impreg. Unit. closed Jack-Liquor & Impreg. Kettles. Also 100 gal. size.
Devine 1000 gal. closed jack agit. steel kettle.
1—2300 gal. vert. agit. Jack Steel Kettle.
8—Jacketed Kettles 50 to 2500 gals.
1—250 gal. Lead Lined Kettle.
2—Pfaudler 500 gal. vert. Glass Lined Tanks.
4—10,000 & 4,000 gal. horiz. Welded Steel Tanks.
New Stainless Steel Tanks 50 to 3000 gals.
50—Stainless Alum., Copper, Glass & Lead Lined Kettles & Tanks. Also new Stainless.
6—Copper Varnish Kettles 150, 200 & 300 gals.

PULVERIZERS & MILLS

Patterson 6' x 8' & 8' x 5' Pebble Mills, motor dr.
Abbe 24" x 33" Pebble Mill. Also Jar Mills.
#1 Raymond Automatic Pulverizer 20 H.P. motor.
1—Raymond #00 Pulverizer 30 H.P. Complete.
1—#0000 Raymond Mills.
1—Hammer Mills & Pulverizers 3 to 50 H.P.
1—Schutz-O'Neill 20" Pulverizer. Also #1.
1—Sturtevant 30" Rock Emery Mill.
1—Robinson 22" Attrition Mill.
1—Lehman 4 Roll W. C. 12x36" Steel Mill.
5—Lehman & Kent 3 Roll Steel Mills. 8"x22", 9"x32", 12"x36", 16"x40".
1—9" x 36" Double Steel Roller Mill.
1—9" x 24" 3 pr. high steel Roller Mills.
3—Houchin 18 x 36". 4 Roll Granite Stone Mills.
4—Ball & Jewell & Leominster Rotary Cutters.
2—U. S. & Premier 1½ H.P. Colloid Mills.

MIXERS & SCREENS

Baker-Perkins heavy duty double arm Mixers, 100 50 & 9 gals. motor driven.
Horiz. Mixers single & double arm to 200 gal.
2—Day & Ross 15 gal. Pony Mixers.
1—Century 2 HP. 4 speed Vert. Mixer.
6—Lead & Paste Mixers 50 to 150 gals.
1—Tyler 3'x5' Vibratory 2 Deck Screen.
Patterson 42" dia. Stainless Conical Blender.
1—Master Drum Type Blender 1000#.
10—Dry Spiral Mixers 50 to 2500#.
12—Portable Elec. Agitators ¼ to 2 HP.

MISC. & SPECIAL

2—Buffalo 6' dia. Vac. Crystallizers.
Gould 75 HP. Centrifugal Pump, 250 PSI.
4—French Oil Motor Driven Expellers.
New 6" x 12" Lab Mixing Mills and Calenders.
4—Farrell 2 Roll Rubber & Plastic Mills.
3—Rubber & Plastic Extruders 1' to 6".
1—Stokes 2E Paste Filler up to 5 gal.
1—Elgin Capper ½ HP. Motor Driven.
1—Marco #200 Stainless Steel Homogenizer.
1—Stokes & Smith & Day Powder Fillers.
6—Filling Machines. Liquid Paste & Powder.
Rotary & Single Punch Tablet Machines, ½" to 3".
1—Howe Mogul Barrel Bag Packer.
2—Revolving Pans 30" & 36".
4—Stokes Vert. High Vac. Pumps.
2—Worthington 12" x 12" x 12" Vac. Pumps.
6—Devine & Buffalo Vac. Pumps.
Soap Machinery for Toilet Laundry Chip Liquid.
Plastic & Rubber Hydr. Presses, Extruders & Injection Molding Equipment.
Roller & Screw Conveyors, Bucket Elevators.
Boilers—Gas, Oil & Coal Fired.

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For Sale **For Sale**

1—Eppenbach Stainless Steel Home Mixer, complete with a 7½ HP Explosion-Proof Motor.
1—Baker-Perkins 100 Gal. Stainless Steel Mixer, double-arm, sigma blades, with 20 hp explosion-proof motor.
1—J. H. Day #2, 75 Gal. Brighton Mixer.
5—Pebble Mills 40 to 500 Gal.
10—Pony Mixers, 8, 15 and 40 gal.
HIGH SPEED Roller Mills 9"x24" to 16"x40".
1—Motor Driven Belt Conveyor.
3—8" Premier Colloid Mills, watercooled.
2—#2SI Mikro-Pulverizers with 10 hp Motors.

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CLASSIFIERS: 4—Akins and Wemco 54" x 33 ft., Simplex, single screw, high weir, with syncregear motor, 220/440 volt, with lifting device. Condition like new, available now. Located Nevada.

FLOTATION EQUIPMENT: 7 banks, 9 cells each, 45 cu. ft. units, complete with blowers, agitators, etc. Used only 6 months, condition like new.

WEMCO SINK FLOAT MOBILE MILL: 360 tons per day, new condition.

LOCOMOTIVE CRANE: Link Belt 25 ton capacity, standard R. R. gauge, gasoline powered, cast steel trucks, air brakes, with or without 1-¼ yd. Williams clam shell bucket, thoroughly modern, excellent condition. Located Minnesota.

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5—8' x 45'—½", 80 LB. PRES.
3—30,000 Gal. 11' x 43' x ⅜" Horiz.
12—10,000 & 20,000 Gal. 5/16" Horiz.
14—8,000 & 10,000 Gal. R.R. Car Tanks.
6—1,000, 5,000 & 10,000 Bbl. Vert.
Located ILL., N. Y., KANS. & GA.
LESTAN CORP. ROSEMONT, PA.

FOR SALE—WE OWN IT OR CONTROL IT!

COLUMNS—STILLS

2 Aluminum Bubble Cap Columns, 36" dia. x 45 plate.
1 Aluminum Bubble Cap Column, 27" dia. x 18 plate.
1 Aluminum Perforated Plate Column, 28" dia. x 36" plate.
1 Copper Column with 18—30" dia. perforated plates and 10—24" dia. bubble cap plates.
4 St. St. T347 Bubble Cap Columns, 6' dia. x 30' H, 20 plate.

CONDENSERS—EXCHANGERS

3 Aluminum tub. 186 sq. ft.
15 Alum. Coil Exch. 47 sq. ft.
7 Copper tub. 20, 65, 90, 140, 1350 sq. ft.
6 S.S. tub. 8½, 14, 190, 236, 368 & 400 sq. ft.
3 S.S. Coil Condensers, 40 sq. ft., 60# pr.

DRYERS—EVAPORATORS

1 Stokes #59A Jacketed Vacuum Rotary Dryer, 18" dia. x 42" long.
2 Atm. Double Drum Dryers, 22" x 38".
1 Buflovak Atm., Double Drum Dryer, 24" x 36".
1 Cummer Rotary Hot Air Dryer, 46" dia. x 26' long.

FILTERS

1 Sweetland #10, 21 leaves.
1 Sweetland #12, 72 leaves.
1 Swenson Rotary Continuous Vacuum Filter; Precoat type, 8' dia. x 8' face, rubber covered and lead acid proof construction.
1 FEINC Rotary Vacuum Filter, string discharge, 4'6" dia. x 6' face, aluminum.
4 Pressure Leaf Filters, 70 to 90 sq. ft.
2 Shriver 36" Filter Presses, rubber covered, closed dely., washing.
1 Shriver 36" C. I. P.&F., 20 ch. cl. dly.
1 Louisville 8-roll Continuous Filter or Grains Press 24".

NOW LIQUIDATING

Equipment of Patrick Henry Brewery, Marion, Indiana:
13—Horiz. Welded Steel Tanks, dished heads: 10,500, 11,300 and 12,700 gal.
6—5500 gal. Vertical Closed Welded Steel Tanks, dished heads.
22—8300 gal. Welded Steel Rectang. open top tanks—16'10" L x 7'7" W x 8'9" H.
1—4000 gal. Vertical Steel Cooker, Jktd., Agit.
1—Dracco Pneumatic Grain Conveying System.
1—Sperry 24" C.I. Filter Press, 16 Ch.
1—Ammonia Compressor with motor: 10 x 10 (82 ton).
1—Steel Shell & Tube Condenser: 1000 sq. ft.
Lot of miscellaneous equipment—pumps, coolers, scales, kettles, tanks, bottling machinery, etc.

JUST PURCHASED

1—AT&M 48" dia. Suspended Centrifugal, St. St. Perfor. basket
1—Stainless Steel T304 Horiz. tank —16,000 gal.
1—Mikro Pulverizer #2—DH
1—N. J. Pony Semi-Aut. Labeler
4—Stainless Steel Bubble Cap Columns, 6' dia. x 30' high, 20 plates, Type 347 St. St.
2—650 ton Hydraulic Presses, 27" x 27", 18" dia. rams.
2—Stokes RD-3 rotary 15-punch pellet Presses.
1—Stainless Steel Pressure Vessel, 600# WP, T304, 18" dia. x 9'4" L.
140—Stainless Steel Flanged Gates Valves, 1", 1½", 2" & 3".
6000 ft. Stainless Steel Tubing, T304, 16 ga., 1½" & 2" OD, 6' lengths.

CHEMICAL PLANT

2—St. St. Jktd. Agit. Tanks, 450 gal.
3—St. St. Vacuum Tanks, 260 gal.
6—St. St. Tanks, 15, 100, 150, 200 gal.
1—St. St. Exchanger, 23 sq. ft.
1—St. St. Column 8" D x 26' H.
3—Adams St. St. Filters.
3—Worthite Pumps.
2—Shriver St. St. Diaphragm Pumps.

KETTLES—REACTORS

1 Stainless Steel, Type 347 Autoclave or pressure tank, 250# pr., Elec. heated 850° F; 17¼" dia. x 9 high.
70 Stainless Steel and Stainless Clad open top, steam jacketed kettles—10, 40, 60, 80, 100, 150, 250, 500 gal. sizes.
3 300 gal. T316 Stainless Steel Jacketed Tanks, 10# jkt. double motion agit.
1 200 gal. Read Stainless Steel Jacketed Kettle, double motion agit. 10 HP.
4 Aluminum Reaction Kettles, Jktd. & Agit., 25, 60, 100 gal. and 250 gal.

MILLS—PULVERIZERS

1 Paul Abbe #8 Pebble Mill, porcelain lined, 32" x 36".
1 Hardinge Conical Ball Mill, Steel Liner, 4'6" dia. x 24" long.
1 Williams Hammer Mill, type AK; size A, stainless steel.
5 Mikro Pulverizers, #1-SH, #1-SI, #2-SI, #2-TH, #2-DH A2DH
2 Premier Colloid Mills, 6" st. st. rotor, type U-3 & V-3.
1 Acme #8½A Jaw Crusher.

TANKS

35 Aluminum Tanks, closed, 4, 275, 330, 480, 500, 1350 & 1450, 9000 gal.
9 Horiz. Welded Steel Tanks, Lastiglas Lined, 15,200 gal.
1 Vertical Rubber Lined, 6000 gal. open.
5 Vertical Jacketed Pressure Tanks—Steel—30# steam jacket—6mm vacuum internally:
3—34" ID x 14' H (approx. 700 gal.)
1—23" ID x 10' H (approx. 230 gal.)
1—23" ID x 9' H (approx. 195 gal.)
8 15,000 gal. Vertical Welded Steel Closed Fermenting Tanks, 80 lbs. WP., turbine agitator with 40 HP motor; 970 lin. ft. 3" pipe coil. Excellent condition.

STAINLESS STEEL TANKS IN STOCK

1 5700 gal. Horiz. T304—NEW.
3 1000 gal. Rectang. open top.
1 1000 gal. Vert. Closed.
50 Stainless Steel Tanks—from 9 gal. to 1000 gal. sizes.
7 3000 gal. Horizontal Stainless Steel Tanks, 5'4" dia. x 18'9" long, insulated and agitated. Excellent for transporting, storage or holding.

MISCELLANEOUS

1 St. St. Bin, T316, 275 cu. ft.
2 Bird Susp. Centrifugals, 48" dia. Stainless Steel Perforated Baskets.
1 Fletcher 30" Jr. Centrifugal Extractor, St. St. Imperf. basket.
5 DeLaval Centrifuges, models #600, 74-11 and 94-01.
2 Kux Machine Co. Model 25 Rotary Pellet Presses, 21 and 25 punch.
3 Stokes Rotary Pellet Presses, 16 punch, B-2, D-3.
4 Selectro Vibrating Screens, stainless steel, 2' x 7', double deck, enclosed.
1 Stainless Steel Horizontal Sterilizer 10# pr., 24" W x 26" H x 36" L.
1 Stokes Vertical Steel Jacketed Vacuum Chamber and Impregnating tank, 30" L x 25" W x 24" D.
2 Vertical Agitators—40 HP gearmotor with Turbo #5B drive, 70 RPM.
1 Porter heavy duty jacketed double worm mixer—75 gal.

STAINLESS STEEL FABRICATION

"Heliarc" welding. Water-quenched welds (if specified). Specializing in lighter weight tanks (10 ga., 12 ga., 14 ga., 16 ga., etc.). Large quantity of type 304 and type 316 sheets carried in stock assuring quick delivery of tanks built to your specifications. Over 30 NEW tanks in stock for immediate shipment—from 30 gal. to 5700 gal. sizes.
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CHEMICAL EQUIPMENT

CENTRIFUGES
24" Bird, type CH, SS.
40" Fletcher, type 304 SS.
40" Tolhurst, perforated.

COLUMNS
24"x94"x½", rubber lined.
6'x29' type 347 SS, 21 trays.
8'x36'x⅜" (2—NEW).

COMPRESSOR—AIR
504 CFM @ 125 PSI w/motor.

CONVERTERS
12,800 sq. ft., 10'6"x36' steel.

DRYERS—MISC
30"x8' Stokes, Mod. 59AB, Vac. rotary
5'x6' Blaw-Knox, Drum, atmospheric.
24"x28' Proctor & Schwartz Conveyor.
6'x35' Louisville Steam Tube, complete.

FILTERS
8'x12' Feinc, rotary, vacuum.
8'x10' & 11'6"x18', Oliver.
No. 7 Sweetland, 172 sq. ft., 41 taps.
36" Shriver, C.I., 36 chambers.
12" Sperry, aluminum, 10 chambers.

HYDRATORS—ROTARY
5'6"x22' Buffalo (2).

KILNS—COOLERS—DRYERS
7'x160'x⅜" (2).
7'x120'x⅜".
7'x60'x⅜".
310-16 Roto-Louvre.
502-20 Roto-Louvre.
604-24 Sta. Steel Roto-Louvre.
5'6"x25'x9/16" Allis-Chalmers.
5'x30'x⅜" Ruggles Cole.
4'6"x40'x⅜" Traylor.

REACTORS—ACID GLASS
400 gal. Pfaudler, ASME.
500 gal. Pfaudler, ASME.

REACTORS—STAINLESS STEEL CLAD
3,000 gal. Jackt'd. ASME (NEW).

STORAGE TANKS
1350 gal. vert. 78"x5'3"x½" ASME.
3400 gal. 7'4"x10'x⅜" type 430 SS.
4100 gal. 5'x28'x¼".
6000 gal. 8'x15'x⅜" vert. ALUMINUM.
6500 gal. TANK CAR TANKS, 76"x28'.
8500 gal. 8'x23'x5/16" vert. (NEW).
12,000 gal. 8'x32'x¼" (NEW).
15,000 gal. 10'6"x23'x¼" (NEW).
135,000 gal. 30'x26' w/coils.

PRESSURE VESSELS
1050 gal. 4'x12'x½" 106 PSI.
1200 gal. 42"x16'x5/16" ASME 125 PSI.
1250 gal. 4'x14' 106 PSI.
1650 gal. 66"x11'x⅝" jktd., glass-lined 150 PSI.
8200 gal. 8'x23'x2" 390 PSI (4).
16,000 gal. 96"x45'x¾" ASME 150 PSI.
30,000 gal. 10'x47' ASME 50 PSI.

MISCELLANEOUS
AUTOCLAVE—2000 gal., jkt. & int. 200 PSI.
REBOILER—2200 sq. ft. 84"x16'x⅜" 960-11/16" tubes, 40 PSI.
CONDENSER—Surface, 1035 sq. ft. Braun.
CONVEYOR—Belt, 18" troughing, 100' cc. rubber covered.
CRUSHER—Two roll, 14"x16" spiked rolls.
DIGESTER—Jktd. 3900 gal. ASME U69, 75 PSI.
ELEVATORS—Bucket, 10' to 50' centers, 5"x5" to 15"x12" buckets.
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1—Pfaudler Closed 250 Gal. Glass Lined Tank.
2—S.S. Condensers 370 Sq. Ft. Ea.
1—Sweetland #12 Filter.
1—Shriver 18" Alum. P&F Filter Press.
1—Sperry 24" C.I. Filter Press, Hyd. Closure.
5—Wd. P&F Presses 18"—24"—30".
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1—Tolhurst Unused 48" Center Slung Cent., Perf. S.S. Basket, 7½ H.P. motor.
1—Bird 12" Steel Sus. Cent. X.P. Motor.
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1—Double Drum Dryer 32" x 90".
1—Buflovak 6' Jack. Vac. Crystallizer.
4—Stokes 212 C Vac. Pumps 100 cfm.
2—Duriron 1½" x 1" S.S. Cent. Pumps.
4—S.S. Jack. Kettles 150 Gal. Ag.
3—Dopp C.I. Kettles 60, 250, & 600 Gals.
2—Mikro Bantam Pulverizers—S.S. & Steel.
1—Mikro 2FF Brze. & S.S. Pulverizer.
1—Rotex Screen 40" x 120" M.D.
3—Alum. Bubble Cap Col's 27" & 36".
2—S.S. 6' Bubble Cap Columns.
2—Erie City 200 H.P. Boilers 150# W.P.
5—Stainless Steel Tanks 100 to 5700 Gals.

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These units are self-supporting bases, motr. driven. Prices and further information on request.

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MILLS—PEBBLE—New Lab. Jars—30x33, 6x8 w/motors.

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RAYMOND #1 w/cyclone.

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KILNS, ROTARY—4 x 30, 5 x 40, 6 x 80.

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20 Unused rubber-lined A.S.M.E. U-69 Code tanks, 11'0" dia. by 56'0". 50 PSI internal pressure. Capacity 40,000 gals. Alterations to suit your requirements. Immediate delivery at $11,000 ea. subject to prior sale. For specifications and additional data, contact TODAY

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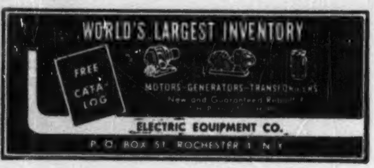

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STILLS and COLUMNS

3476 Copper Jacketed Still Pot: 28"x25" with condenser.
3659 R3 Aluminum Bubble Cap Column: 27½"x36': 60 plate.
3564 Copper Bubble Cap Column: 18"x12': 24 plate.
C13-140 Stokes: 1000 Gal. Copper Bubble Cap Column: 36"x18'.
C14-141 Stainless Packed Column: 24"x14' Insulated.
C14-150 Steel Absorption Column: 12"x10': 20 cu. ft. raschig rings.
C14-151 Solvent Recovery Absorber: 8'x28' with accessories.
C14-152 Steel Scrubber Column: 36"x20': domed heads.
C14-153 Gas Saturating Tower: 8'x36'6": 5 PSI.
C15-154 Fractionating Tower in 2 sections: 24"x51': 230 cu. ft. raschig rings.
3585 Stainless Flash Tank 8'x6' Type 316 S/S: with S/S Tube Bundle.
2755 Steel Still: 54"x96" with steel receiver 54"x96".
C14-136 HCL Absorber: 15"x16'6" high with accessories
C14-137 Stainless Steel High Pressure Scrubber: 12"x4'.
2018 Monel Water Distillation Apparatus compression type: 22"x67".
9908 H2 Copper Jacketed Vacuum Still: 38½"x42".
9908 H3 Aluminum Steam Jacketed Vacuum Still: 40"x60".
E13-161 Harris Stainless Vac. Still with S/S coils: 6'x30'9" with accessories.
E13-162 Nickel Clad evaporating Still: 6'6"x10'.
3470 Stainless Steel Bubble Cap Column: 15 sections: 8½"x19' high.

BALL and PEBBLE MILLS

M3-25 Patterson Steel Ball Mill Type D: 2'x3': 7½ HP motor, balls, etc.
M3-26 Abbe Steel Ball Mill: 2'6"x3'6": 7½HP with steel balls.
M3-27 Moore Jacketed Ball Mill: 4'x5': 15 HP XPL Gearhead motor.
3443 International 8'x8' Porc. Lnd. Pebble Mills: 50 HP Gearmotors.
M14-28 Patterson Buhr lined Pebble Mill: 2'6"x3'6": direct drive.
M14-29 Patterson Porc. Lined Pebble Mill: 3'6"x4': direct drive.
3564 Abbe 50 gal. Porc. Lnd. Pebble Mill: 20"x30".
M14-195 Abbe Buhr Lined Pebble Mill: 32"x36": 2 HP motor.
3483 Abbe buhrstone Lined Pebble Mills: 54"x60": arr. direct drive.
3673 Large Stock of Jar Mills: single or multiple: all sizes.
M14-209 SZEGVARI No. 100 Attritor: complete with 7½ HP motor.
M14-201 Patterson Porcelain Lined Pebble Mill: 30"x42": 25 HP motor.
M14-197 HK Porter Porcl. Lined Pebble Mill: 5'x6': 25HP motor.
M14-196 Patterson Buhrstone Lined Pebble Mill: 6'x10': 10 HP.
M8 Hardinge Conical Ball Mills from 22"x6' to 4'x10': motorized.

SIFTERS—SCREENS

S5-250 Orville Simpson Rotex Sifter: 20"x48": single deck: motorized.
S5-251 Rotex Sifter 30"x80": 3 deck: 4 outlets: 1½ HP XPL motor.
3678-C3 Rotex Sifter: deck: 3 separation: 40"x86".
S5-252 Patterson GyroCentric No. 300: 20"x84" S/S: 1 HP motor.
3515 Southway S/S Shaker Screen: 40"x90" with 1 HP motor.
10085-7 Sprout Waldron Gyratory Screen 40"x72" with 7½ HP motor.
S5-253 Gump Bar-Nun Sifter: 32"x60" motorized.
S5-254 Selectro S/S Screen 18"x48" single deck.
S5-255 Selectro S/S Screen double deck 24"x72".
S5-240 Selectro 18"x60" Steel 2 deck Screen V drive.
S5-237 Simplicity Vibrating Screen 3'x10' single deck.
S5-238 Bonded Scale Double Deck Oscillating Screen: 4'x12': V belt.
S5-244 Tyler Hummer Screen: 3'x5' with converter, exciter and motor.
3484 A33 Sutton Steele Separator Model B 100 with 5 HP motor.

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Because our staff has been supplying good rebuilt equipment for over 25 years, the versatile experience gained has given us decided advantages over most fabricators.

The FIRST MACHINERY CORP. has been delivering NEW special fabricated equipment in Stainless Steel and most other metals in record fast time because of our highly organized specialty divisions.

MIXERS (Heavy Duty Dough and Mass Mixers)

3293 E5 J. H. Day S/S 5 gal. Double Arm Jktd. Mixer! Vacuum Cover.
3566 Baker Perkins S/S Double Sigma Arms: 12"x8½"x10": 2HP XPL.
3166 J. H. Day 20 Gal. Jacketed Mixer: cored masticator arms: 5 HP.
2949 Ross No. 2 Double Arm Mixer: 16"x12"x16" with 3 HP motor.
M26-214 J. H. Day Mogul 5 Gal. Jktd. Mixer: Vacuum Cover: 7½ HP motor.
3533 E 3 J H Day No. 2: Jktd. 20 Gal. Double Arm Mixer: 20½"x16"x16".
M25-212 J. H. Day Cincinattus No. 4 Sigma Arm Mixer: 50 Gal.
M26-213 J. H. Day Jktd. Hor. Mixer: 30"x35"x68" with 5 HP PL motor.
2109 J. H. Day Jkt. Ribbon Mixer: 175 Gal. 28"x26"x70".
2337 W. & P. Type Jktd. Double Arm 100 gal. Mixers geared both ends.
3677 D1 Baker Perkins Size 17 Class BB Type VII Shredding type jacketed Mixers: double sigma arms: geared both ends: 43½"x53"x44".
M13-152 Simpson 24" Laboratory Size Mix Muller.
3668 S2 Lancaster Mix Muller No. 3 with Skip Hoist
3427 Lancaster Model EAG4 Mix Muller complete with all accessories.
M13-151 Simpson 6' Mix Muller No. 2 with 25 HP motor and accessories.
M13-135 Simpson Mixer No. 1 48"x18" with 27"x5" Muller: 7½ HP.
2986 K6 Savage 200 lb. Marshmallow Beaters.
2682 J. H. Day Jacketed Egg Clipper Mixer: 20"x22"x28".
R1-225 Farrell-Birmingham Banbury Mixer 1A with 100/150 HP motor.
R1-226 Farrell Birmingham Banbury Mixer No. 3 newly rebuilt.
R1-224 Farrell Birmingham Banbury Mixer No. 11: 600/450 HP motor.

RENTAL-PURCHASE PLAN

REACTORS

3424K4 Stainless Reactor: heated agitated: 24"x48".
3661 Stainless Jktd. Agitated: 18"x24" with condenser.
3417 Stainless Jktd. Agitated Reactor: 24"x40".
3549 Stainless Jktd. Autoclave: 300 psi: Agitated: 10"x15".
3673L9 Pfaudler Glass Lined Jktd. Reactor: 16"x20".
3544 Pfaudler Glass Lined Jktd. Reactor: 4'x4': 75 PSI.
3320 Stainless 250 Gal. Agitated Reactor: 36"x50".
3424K2 Monel 250 Gal. Jktd. Agtd. Reactor: with Condenser and Accessories.
3670 Steel Reactor 4'x4' heated with copper coil unit.
3424K9 Stainless 475 Gal. Reactor 4'x5' Jacketed and Agitated.
3168 Stainless 500 Gal. Jacketed Reactor: 6' dia. x30" straight side.
3168D7 Doppley Jacketed Reactor: 48"x8' high.
3390 Buffalo 500 Gal. New Jktd. Agtd. Reactor: 4'x5'2" motorized.
3273 Pfaudler Glass Lined Jacketed, Agitated Reactor: 47"x67".
3434 Dopp 650 Gal. Cast Iron Full Jktd. Agitated Reactor: 80"x67".
R4-230 Stainless 600 Gal. Reactor with Reflux Condenser: 5 HP agitator.
3327 Copper Steam Jktd Vacuum Reactor: 650 gal. 54"x7'.
3113E2 Copper Vacuum Pan: coil heated: 2000 Gal. 7' diameter.
R4-227 Cast Iron 1000 Gal. Nitro Pot: 6'x6': Agitated 5 HP motor.
3598 Steel 2600 Gal. Jktd. Agt. Reactor: 8'x7'.
R4-231 Stainless Reactor: 2800 Gal. 7'6" dia. 125PSI internal.
R4-229 Steel Reactor: 3000 Gal. 10'5"x4'10": Jacketed: Agitated.
R4-225 Steel Reactor: 3500 Gal. 6'x16'6": Jacketed: Agitated.
2755 Steel Reactor: 54"x96" with steel Receiver, same size.

DRYERS (Atmospheric)

308391 P. & S. Continuous Apron Dryer: 12 Section: 43'6"Lx7'4"Wx14'6"H.
366891 P. & S. Apron Dryer: 13 unit: 8'W.x78'1 complete with accessories.
D8-147 P. & S. Apron Dryer: 12 Section: 5 Pass S/S belt: 7'4"W.x36'L.
3168 Louisville Monel Counter Current Atmospheric Dryer: 38"x16'.
D11-155 Louisville Rotary Steam Tube Dryers 5'x28' to 6'x50'.
D11-154 Davenport Rotary Steam Tube Dryers up to 6'x40'.
D11-158 Huhn Direct Fired Rot. Dryer: 3'x12' with accessories.
D11-159 Hersey Monel Direct Fired Rot. Dryer 3'x24' with accessories.

DRYERS (Rotary)

3306 Horizontal Steel Rot. Dryer or Cooker: Vac. Jkt. Agt. 4'x7'7½".
3382 Rotary Vacuum Dryer: 52"x102" with agitator and 10 HP motor.
D6-147 Stokes No. 59AA Rotary Vacuum Dryer: 24"x72" with accessories.
D6-144 Stokes 59B Rotary Vacuum Dryer: 40"x15' long with accessories.

DRYERS (Drums)

1300McA Struthers Wells S/S Drum Dryers 5'x10' with accessories.
3026 Buffalo Rot. Vac. Drum Dryer: chrome plated 5'x12' complete.
3414 Rotary Drum Dryer in NICKEL: 48"x46".
3316 Bagley & Sewell Double Drum Dryer: 28"x60".
D5-150 Buffalo Double Drum Dryers: 32"x100": 42"x100" and 60"x120".
D5-151 Buffalo Twin Drum Dryers: 32"x72" and 32"x92".

EVAPORATORS

1060C102 Goslin Birmingham Steel Sextuple Effect, 58,200 sq. ft.
3274 Swenson Quadruple Effect Long Tube Evaporator: film type.
3475 Zaremba Single Cast Iron Evaporator: 130 sq. ft. Copper tubes.
2898 Devine Single Cast Iron Calandria type: 28"x8'.
3518 Acme 1000 Gal. Copper 6'x10', coils, barometric condenser, etc.
3557 Croll Reynolds Vac. Evaporator: 16"x8' MONEL with accessories.
3670 Copper Vac. Evaporator: 66"x73" coils, heat exchanger.
487 Zahm & Nagel Continuous Evaporator: 2500 lbs. per hour.
E12-161 Buflovak Double Effect Evap. C.I. with copper steam chest, Barometric Condenser, etc. 75 and 100 sq. ft. each.
E13-162 Stainless Evaporator 6: dia. 285 sq. ft. coils: jktd Bottom.
349757 Jacketed Crystallizing Evaporators: 24"x21"x12' long.

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105 CFM Ingersoll (Oil) 2 Pneu
105 CFM Worthington (Gas) 2 Pneu
105 CFM Worthington (Gas) 4 Pneu
160 CFM Worthington (Gas) 2 Pneu
160 CFM Worthington (Gas) 4 Pneu
210 CFM Worthington (Gas) 4 Pneu
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276 CFM Chicago 12x6
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800 CFM Worthington 18x9
1035 CFM Worthington 21x9
1184 CFM Worthington 22x9
1633 CFM American 24x11

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La Bour Acid Pumps
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32" x 90" & 36" x 120" Double Drum Dryers.
2000 gal. Horiz. S.S. Tank, insul., agit.
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26" Centrifugal Extractors, copper baskets.
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Model 148C Stokes High Vacuum Pump, 1½ H.P.
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30 ton Howe Suspension Tank Scale.

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E—Evaporators Steel, 350 and 3500 gals.
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T—Tablet Machine, Stokes RD 4 Complete

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E—Eimco 8' x 8' Vacuum Filter Complete
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20—Jacketed Kettles—Stainless, Copper, Aluminum.
1—Day mixer, Steam Jacketed, 50 gal. Sigma Blade.
1—Robbins Vibrex 3x6 Vibrating Screen, single deck.
1—Copper Evaporator, steam jacketed, 9'1"x3'8".
60—New Pressure Cookers, 18"x18" & 24"x28".
50—Pumps—steam and electric.
1—New Glass Nash Centrifugal Pump, 100 gpm.
1—Jeffrey Vibrating Conveyor 15' lg. 12" wide.
1—Buflovak Jacketed Impregnating Tank 42"x32".
1—4x8 Sturtevant Jaw Crusher.
1—Ribbon type Mixer, steam jacketed.
1—Model 16 Sharples Stainless Steel Centrifuge.
3—New Drum Rollers.
1—A. F. Bartlett Hog Mill & 7½ H.P. Motor.
10—Tanks, 9'6"x30'—15,500 gal. each.
3—Stainless Steel Jacketed Filters.
1—Gaulin Stainless Steel Homogenizer, Type CGC, 125 gph, with 5 H.P. 3 phase motor—like new.
1—Shriver 18" Aluminum Filter 9-plates, 9-frames.
4—Stokes Rotary Tablet Machines RD4.
10—New Sharples Oil Purifiers.

SPECIAL: 3—Dope Kettles with Agitators, 725 gal. cap.—like new.
3—Tankcar Tanks 10,000 gal. each, with coils—used for molasses.
2—Large Steam Jacketed Horizontal Mixers.

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3—PFAUDLER 3000 GAL. GLASS LINED STORAGE TANKS. Model POW, open top, welded construction, each 8' dia. x 8' deep, 3" bottom outlets.

1—LIGHTNIN' MODEL SEV 750 SIDE ENTERING AGITATOR with 20" monel propeller and bearing.

1—INTERNATIONAL SIZE, NS-6 SIDE ENTERING AGITATOR with 3 HP motor.

2—FEINC 5' x 3' MONEL VACUUM FILTERS, string discharge, complete with wash and compression mechanism including agitator, motors, Nash L-3 vacuum pumps, 14" x 24" monel receiver, Worthite 1 CG-1 motor driven circulating pump. SEE PHOTO

3—BUFLOVAK MONEL EVAPORATORS, now arranged as double effect 148 sq. ft. per effect, one effect rapid concentration type, other effect vertical tube calandria, third effect 145 sq. ft. vertical tube calandria; can be used as 3 single or one triple effect, complete with condensers, ejectors, salt chambers, piping and all supports and accessories. SEE PHOTO

RECENT PURCHASES

- **2—Shriver 18" S.S. Filter Presses**
- **4—Devine and Buflovak, 20, 17, 13 and 9 Shelf Vacuum Shelf Dryers. Single and Double Door.**
- **1—Haveg 1000 gal. Tank.**
- **6—150, 225, 350 and 625 gal. S.S. Vacuum Stills.**
- **3—Sweetland, #12, #7, and #5 Filters.**
- **1—Bird-Young, S.S., 4' x 2' Filter.**

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1—HERSEY 3' x 24' MONEL ROTARY DRYER, direct fire counter current for either natural gas or #3 oil motor drive with 3 HP motor, and #300 American Blower Fan. SEE PHOTO

2—MONEL STAND PIPES 12" OD, 1—5', 1—12' high.

1—WALLACE & TIERNAN CHLORINE EVAPORATOR, hot water recirculating type 50,000 BTU per hr. with pressure reducer and shut-off valve and flow meter.

1—RAYMOND FLASH DRYER, consisting of **#40 RAYMOND IMP MILL,** furnace, 40 HP motor, 6" x 20' screw conveyor, 8" double paddle mixer, recorder controller, and 16" belt conveyor. SEE PHOTO

1—SYNTRON ELECTRICAL VIBRATORY COOLER MODEL F-45 20" OD x 16" ID with cooling fins. Projection inward 3", length 5'10".

1—KENNEDY #25½ GYRATORY FINE REDUCTION CRUSHER, roller bearing, gearless type with 40 HP motor and spare parts, Serial #1618.

1—KENNEDY SMOOTH ROLL CRUSHER 24" x 10" heavy duty chrome steel rolls, one roll smooth, other roll has Stoodite steel tips, 2—10 HP motors.

1—KENNEDY 4' x 60' ROTARY KILN, ½" plate, welded, with firing hood, airseal, self aligning bearing. 10 HP motor and variable speed drive. SEE PHOTO

2—KENNEDY VIBRATING SCREENS type A 3' x 8' totally enclosed construction, 5 HP motors, one double deck, one single deck.

4—KENNEDY BUCKET ELEVATORS, #13 mill type malleable iron chain, totally enclosed, 5 HP motors, 8" x 5" buckets, 42'5", 37'6", 37' and 25' centers.

1—SLY AUTOMATIC CONTINUOUS DUST FILTER No. 68 TYPE 360 with exhaust fan, 4488 sq. ft. filtering area, vent fan and 15 HP motor.

GLASS LINED VALVES AND FITTINGS.

1—SLY AUTOMATIC CONTINUOUS DUST COLLECTOR No. 34 TYPE 360, capacity 2244 sq. ft. of filtering area with dust fan and 10 HP motor.

1—ERIEZ PERMANENT MAGNETIC PULLEY 18" x 18".

2—MONEL CLAD BINS 5'5½" x 5'5½" x 7'.

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1—ACME JAW CRUSHER, 9" x 16" size 8½ A, manganese jaws, with 30 HP motor.

2—EXACT WEIGHT SACKING SCALES, pedestal type.

1—KENNEDY CONTRA-FLOW GAS MIXING CHAMBER with explosion cone and combustion zone.

1—14" x 15' BELT CONVEYOR with 1½ HP motor.

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2—DURIRON MONEL PUMPS, Model 30 series DEST 9½, 100 GPM at 25' head.

2—DURIRON MONEL PUMPS, Model 40 series M7B60, 100 GPM at 25' head.

2—DURIRON MONEL PUMPS, Model 40 series M7MD70, 100 GPM at 25' head.

1—DEMING MONEL PUMP, Figure 40 BM #1 Standard motor drive, 2 HP motor, 50 GPM.

2—DEMING MONEL PUMPS, Model B type 1-RV, 1½ HP motors, 50 GPM.

1—LAWRENCE 1¼" HASTELLOY C PUMP, 5 GPM at 40' head.

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1—Kemp 400CFM. Dynamic Dryer.
1—Davenport #3A bronze rotary Press.

Centrifugals and Clarifiers

1—30" Tolhurst suspended imperf. basket.
1 set 3—36" American suspended (two with stain. steel perforate basket.)
1—40" Tolhurst suspended rubber covered perforate basket.
2—De Laval 54-81 Clarifiers, 3 hp.
3—Sharples airtight Clarifier, stain. steel, 3 hp.

Evaporators and Vacuum Pans

1—New 36" Henssey st. steel Pan.
1—Rogers 42" st. steel dbl. effect Pan.
1—20 gal. Stokes st. steel Vacuum Pan.
1—Swenson sgl. eff. Evap. 120 sq.ft.
1—Swenson quad, eff. Evap., 3500 sq.ft.
1—Zaremba trip. eff. Evap., 1500 sq.ft.
1—Swenson trip. eff. Evap., 850 sq.ft.

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12—Cast Iron recessed and plate and frame Filter Presses, 7" to 36".
1—Aluminum 30" 40-chamber P&F. press.
1—Lead 24" 30-chamber P&F. press.
1—Oliver 3x4' phosphor bronze.
1—Oliver 8x14' Filter.
1—Oliver pressure, iron, 110 sq.ft.
5—Alsop, Lomax internal pressure Filters, stain. steel and bronze.

MILLS

1—Attrition, Sprout-Waldron 20".
12—Pebble and Jar Mills, 1 to 235 gal.
5—Colloid Mills and Homogenizers, 3 to 15 hp.
10—Hammer Mills, ¾ to 50 hp.
2—Pot Mills, cast iron, 18 and 36".
6—3-roll Mills, Day, 12x32" and 16x40".
1—2-roll Rubber Mill, Birmingham, 12x24".

MIXERS

1—Readco 250 gal. work. cap. stain. steel dbl. arm, 50 hp.
7—Baker-Perkins, Read, Lynn-Superior dbl. arm, 1 gal. to 100 gal.
2—Day 3000# jacketed horizontal ribbon.
10—Day, Robinson Powder type, 50 to 2000#.
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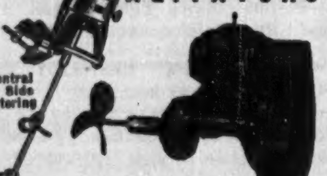

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- 2—Oliver Rotary Vacuum Filters, 5'3" x 6', Steel Construction with Monel Screens.
- 1—Bird 24" Monel Screen Type Centrifugal Filter.
- 1—Oliver Homogenous Lead Filter, 8' x 8'.
- 1—Sperry Aluminum Plate & Frame Filter Press, 42" x 42", Closed Delivery, 3" Frames, 35 Chambers.

DRYERS—KILNS

- 1—Vulcan Rotary Kiln, 7'x120'.
- 7—Devine Vacuum Shelf Dryers, 5, 9 & 20 Shelves.
- 1—Buflovak Double Drum Dryers, 32"x90".
- 1—Louisville Steam Tube Dryer, 6'x50'.
- 2—Buflovak Vacuum Drum Dryers, 24"x20".
- 1—Devine Rotary Vacuum Dryer, 5'x25'.
- 2—Buflovak Double Door Vacuum Shelf Dryers, 20 shelves each.

FILTERS

- 1—Shriver Stainless Steel Filter Press, 24"x 24", Closed Delivery, 10 Chambers.
- 3—Shriver 24"x24" Aluminum Plate & Frame Filter Presses, Closed Delivery. 35 Chambers each.
- 1—Sperry 42" C I Plate & Frame Filter Press, 16 Chambers, Closed Delivery.
- 1—Sperry 12" Bronze Plate & Frame Filter Press, Closed Delivery, 9 Chambers.
- 1—Shriver 42" Evedur P&F Filter Press, 40 Chambers. Closed Delivery.
- 3—Shriver 36"x36" C I P&F Filter Presses, Closed Delivery, 24 & 25 Chambers.
- 5—Sweetland Filters, #2, 5, 7 and 12.
- 1—Oliver Rotary Steel Filter 3'x1'.
- 1—Shriver 24"x24" cast iron, closed delivery, filter presses, 3 eye, 23 chambers.
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- 2—A. T. & M. S S Susp. Centrifuges, 48" Imperforated Baskets.
- 1—Fletcher 40" Centrifuges, Bronze Perforated Basket with Motor.
- 1—Tolhurst Stainless Steel Suspended Type Centrifuge, 40" Imperforated Basket.
- 1—Fletcher 48" Centrifuge, Bronze Perforated Basket. Motor.
- 1—Sharples Stainless Steel Super D Canter, Model PN-14.
- 6—Sharples #16-Y Stainless Steel Super Clarifying Centrifuges.

1—Buflovak Type 347 Stainless Steel Rotary Vacuum Dryer, 5' x 20' with all auxiliary equipment.

MIXERS

- 1—Baker Perkins S.S. Jacketed Double Arm Mixer, Sigma Blade, 9 gal.
- 3—Baker Perkins Steel Jacketed Mixers, 200 gal. Working Cap., Sigma Blades.
- 1—Nettco Drive, Model WT 27, output speed 16.
- 1—Banbury Mixer #1.
- 1—Simpson #1 Intensive Mixer.
- 4—Baker Perkins Steel Jacketed Mixers, Sigma Blades, 100 Gals.
- 3—Baker Perkins Stainless Steel, Jacketed Mixers, Sigma Blades, 100 Gals.
- 1—J. H. Day Jacketed Powder Mixer, 5000 lbs. Center Discharge.
- 3—Turbo Steel Jack. Mixers, 700 Gals. Each.
- 12—Simpson #0 Intensive Mixers "Unused".
- 1—Readco Stainless Steel Jacketed Double Arm Jacketed Mixer, Sigma Blades, 225 Gals.
- 1—Baker Perkins Stainless Steel Dispersion Mixer, Size 15, Type VUMM, 100 gals. working cap., 150 gals. total cap., 75 HP Drive.

PULVERIZERS—GRINDERS—MILLS

- 1—Stewart Bolling 2-Roll Mill, 6"x12".
- 1—Mikro #3TH Mikro Pulverizer with 30 HP Motor.
- 1—Mikro #3W Pulverizer.
- 1—Mikro #2TH Pulverizer, Stainless Steel & Bronze Construction, with Motor.
- 1—Abbe #2 Master Rotary Cutter.
- 1—Ball & Jewell #0 S.S. Rotary Cutter.
- 2—Ball & Jewell #2 Rotary Cutters.
- 1—Blaw Knox Air Mill Pulverizer.
- 1—Mikro Stainless Steel Atomizer #6.
- 3—Thropp 2-Roll Rubber Mills, 18"x50".
- 1—Abbe #2 Buhrstone lined Pebble Mill, 5'x4'.
- 1—Gruendler #24-40 Hammer Mill.
- 1—Thropp 2-Roll Rubber Mill, 10"x24".
- 1—Sprout Waldron #36 Attrition Mill with 2-75 HP Motors.

- 1—Pfaudler Glass Lined Jacketed Vacuum Reactor, 500 Gals. Cap.
- 1—Pfaudler Glass Lined Jacketed Kettle with Anchor Type Agitator, 150 Gals.
- 12—Koven Stainless Steel-clad Jacketed Vacuum Kettles, 380 Gals. Cap.
- 1—Combustion Engineer Stainless Steel Jacketed Autoclave, 500 Gal. 300 PSI.
- 1—Patterson Stainless Steel Autoclave with Turbine Agitator & Explosion Proof Drive, 200 Gal., 225 PSI.

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- 1—Monel Storage Tank, 1,300 Gals.
- 2—Blaw Knox Steel Jacketed Autoclaves, 300 & 500 Gals. Cap., P.S.I. Working Pressure 500 Lbs.
- 1—Glascote glass lined Jack. vac. reactor, 1600 gals. cap. (Unused).
- 1—Patterson Steel Jacketed Autoclave, 900 Gals. Cap., Internal Pressure 120 Lbs.
- 1—Artesian Steel Jacketed Kettle, 1,000 Gals. Cap., with Rake Type Agitator, ASME Code, 50 Lbs. Pressure.
- 2—J. P. Devine Jacketed Vacuum Reactors, 2,000 Gals. Cap. Each.
- 1—Buffalo Steel Pressure Tank, 10,000 Gals. Cap.; 125 PSI, ASME Coded.
- 25—Steel Storage Tanks, 9,000-17,500 Gals.
- 1—Steel Rubber Lined Storage Tank, 4,500 Gals. Cap.

MISCELLANEOUS

- 3—Downington Stainless Steel Heat Exchangers, 45 & 500 sq. ft.
- 1—Struthers Wells Hastelloy B Heat Exchangers, 450 sq. ft. "Unused".
- 1—Worthington Worthite Pump, with 7½ HP Motor, Model #3CT1A.
- 3—Nash Hytor Vacuum Pumps, Model #TS-12.
- 1—Alco Stainless Steel Heat Exchanger, 60 sq. ft.
- 1—Ambaco Model 3A Heavy Duty Horizontal Continuous Baler.
- 1—Vulcan Copper Condensers, 300 sq. ft.
- 1—Dayton Dowd Centrifugal Pump, Stainless Steel, Size 1CS, 35 GPM at 40' head, speed 1745 RPM, 2"x1".
- 2—Worthington Antactron Centrifugal Pumps, Model #3 CU1, 4"x3".

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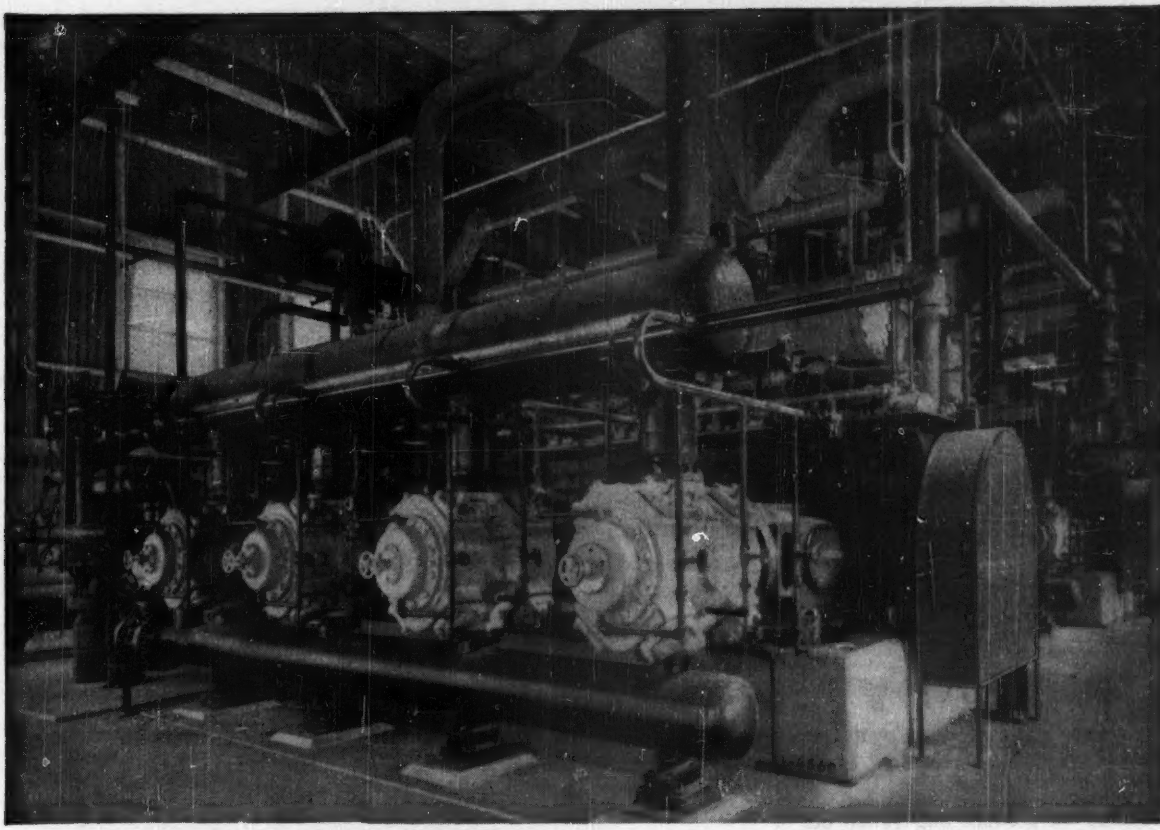
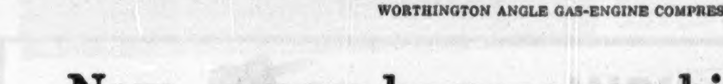
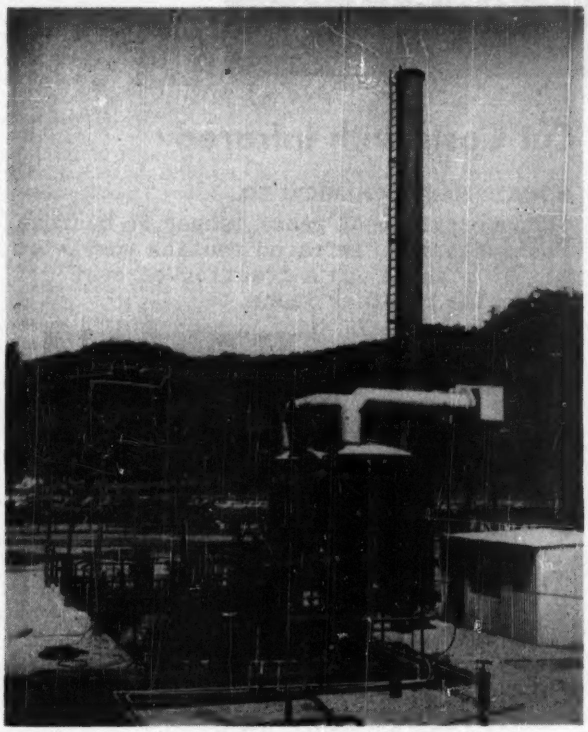


WORTHINGTON ANGLE GAS-ENGINE COMPRESSOR installation in a gas pipeline pumping station.



BETH-TEC HEATING SYSTEM...
...up to 1000°F WITHOUT PRESSURE



BETH-TEC system at the plant of a large organic chemical manufacturer.

Standard Design

BETH-TEC process systems anticipate the requirements for efficient industrial heating and cooling duty in the range from 700°F to 1000°F.

- SAFETY—The heat transfer medium has negligible vapor pressure. It is non-toxic, non-corrosive, non-fouling, chemically stable, and inexpensive.
- SIZE RANGE—Standard units available for duties from 500,000 to 5,500,000 Btu/hr. Designs for other duties can be provided.
- EASE OF INSTALLATION—Constructed in several large sections for easy installation with minimum erection costs.
- COMPLETE—Furnished with salt pumps, tanks, piping, and instrumentation, as required.
- ECONOMICAL—Maintenance and operating costs are low.

Beth-Tec systems are also custom-made to meet special requirements such as severe process duties, heat removal from reaction vessels, special instrumentation, etc.

Beth-Tec systems can also be adapted for high temperature heat transfer media other than molten salts.

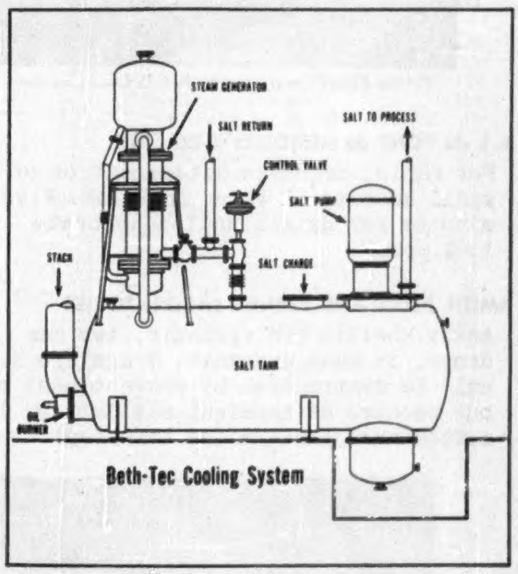


Diagram of typical BETH-TEC system for cooling application.

For full details regarding Beth-Tec units, write

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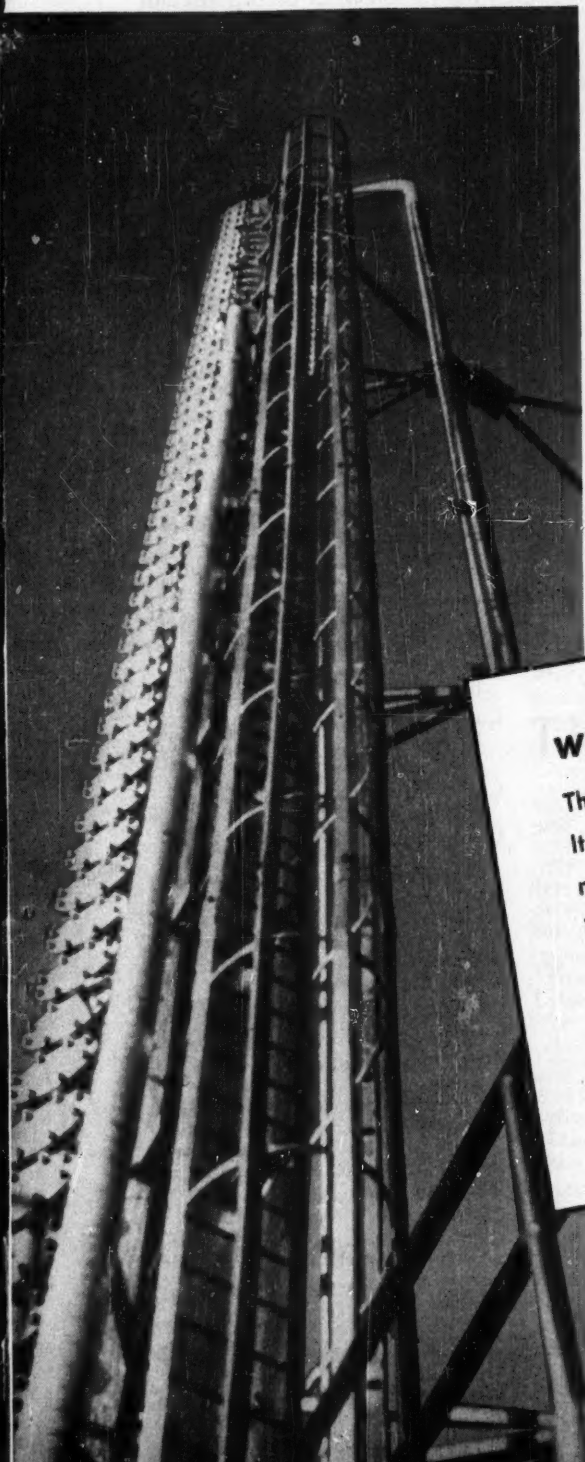

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This department can serve you in three ways. It is a complete classified directory to equipment, chemicals and services offered in this issue of Chemical Engineering. It is a key to the Reader Service postcards (inside back cover) that will bring you free additional information on any of the listed items. You can also use the Reader Service postcards to order reprints of Chemical Engineering reports and articles.

Chemical Engineering Reader Service

How Reader Service Works

The Reader Service postcard inside the back cover makes it easy to get more information on any of the chemicals, equipment or services listed here. The card has corresponding numbers for each of the key page numbers in this directory. Circle the numbers of the items you want; fill out the return address; mail the card to us. Answers will come direct to you from the companies. The letters, L, R, T, B, locate ads on the page: left, right, top, bottom. The letters a, b, c and A, B, C indicate first, second, third, etc., item in an ad or on a particular page.

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Flashback . . .

To make sure that you don't miss any news that could help you with your job, Chemical Engineering is doing a double take for you. The listings on this and the following page is a repeat of the editorial listings only on chemicals, equipment and services featured last month in the New Equipment, New Products and New Technical Literature departments. Use the postcard below for more information on any item in this list.

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